

Workshop

**From science to praxis:
Experiences employing
Geophysical methods
to characterize
Geothermal anomalies**

26 mayo - mai - May 2021
9:00 - 13:30

***“Geophysical hydrocarbon
exploration data and
Deep Geothermal research:
Two feasibility projects in Spain.”***

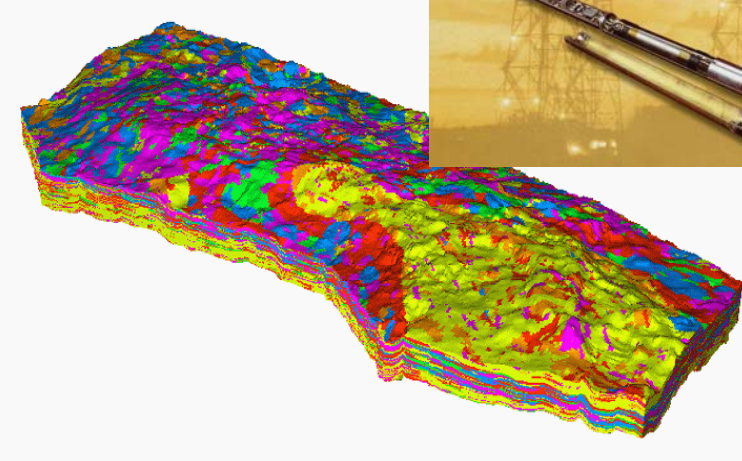
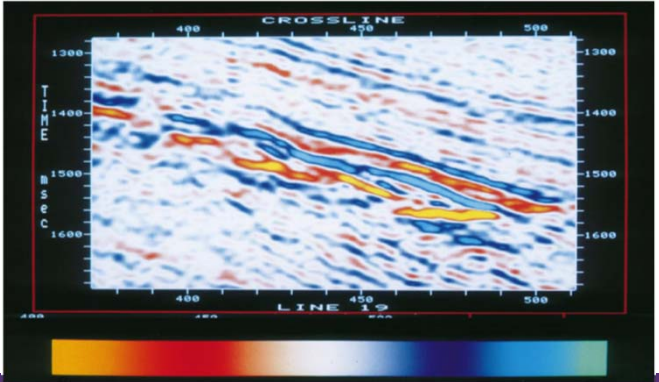
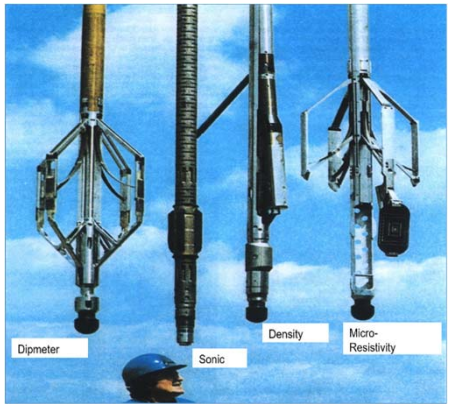
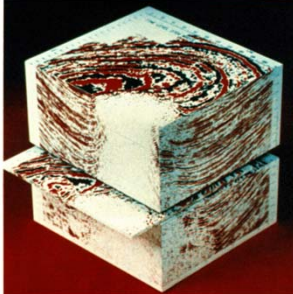
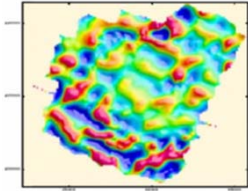
**Experiencias de la aplicación de la Información
Geofísica procedente de la Exploración de
Hidrocarburos a la Investigación de Recursos
Geotérmicos Profundos en España**

Juan Klimowitz & Enrique Hernandez

 **Gessal**

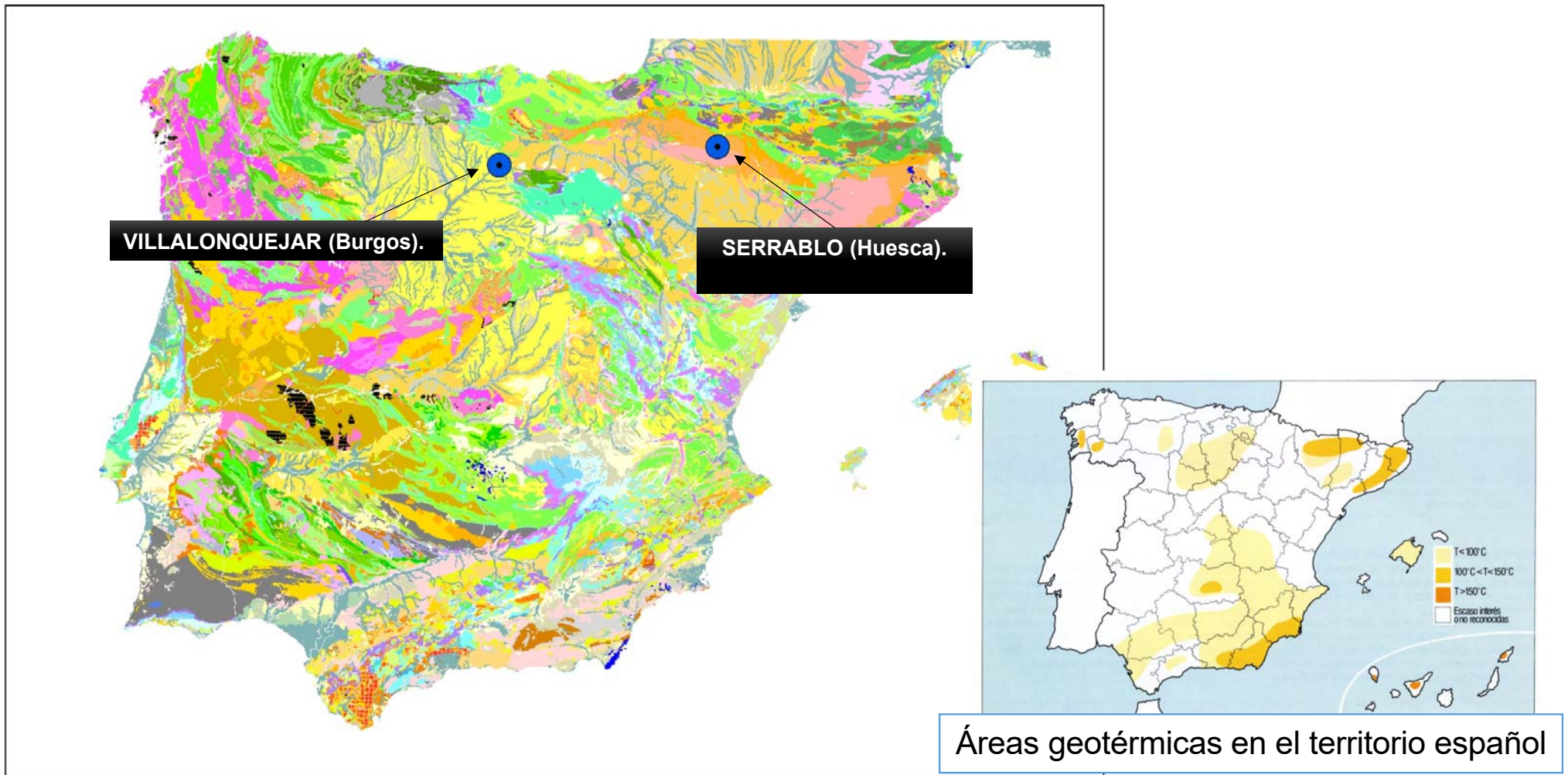
Geophysical Prospecting in the Hydrocarbon Exploration

- Regional Geophysical prospecting
- Local Geophysical prospecting
- Detail Geophysical characterization



Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.





Geophysical hydrocarbon exploration data and Deep Geothermal research:
 Two geothermal feasibility projects in Spain.



PROYECTO VILLALONQUEJAR – BURGOS (Loreal)

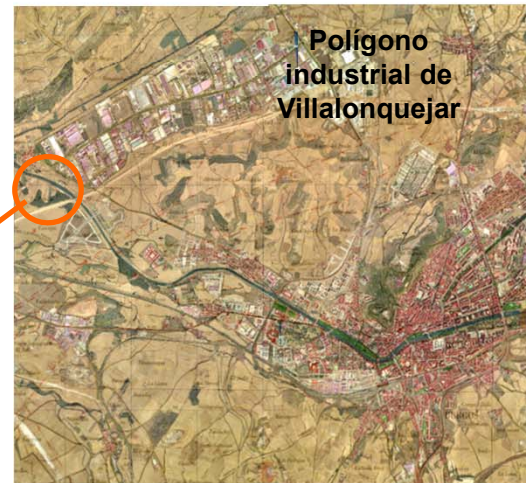
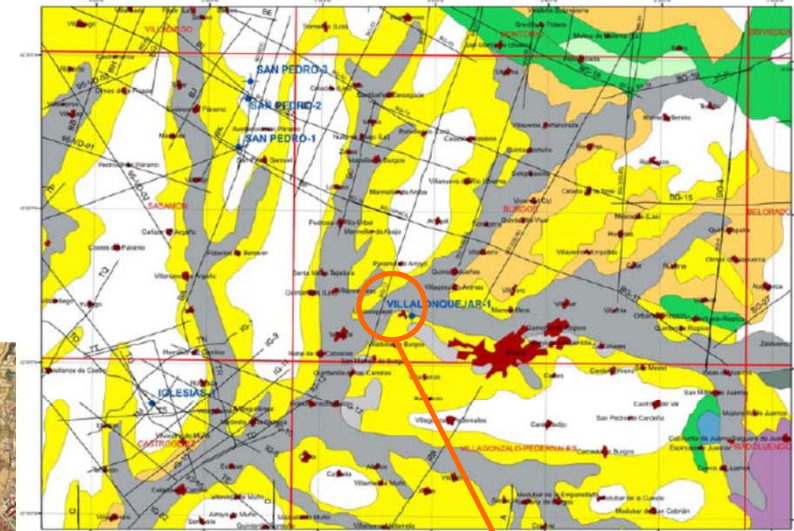
1970-1975---IGME y ENADIMSA: el *“Inventario Nacional de Manifestaciones Geotérmicas”*: Cuenca del Duero. Sondeo Iglesias-1 (1955). Acuífero 65°

1975-1978- ENAGAS & ENADIMSA Proyecto de Almacenamiento subterráneo de gas.

1978, ENADIMSA realizo un estudio para el posible aprovechamiento geotérmico de los acuíferos profundo en el área de Burgos, el cual tuvo como resultado la perforación del sondeo **Villaloncejar-1**, en 1981.

1998, La Diputación provincial de Burgos, a través del Instituto Tecnológico Minero de España ITGE, realizo el *“Atlas del Medio Hidrico de la Provincia de Burgos”*

2009, GESSAL realizo para una empresa del polígono de Villaloncejar una revisión de los estudios previos para el posible aprovechamiento geotérmico de los acuíferos profundo en dicho polígono industrial,



VILLALONQUEJAR-1
Enadimsa 1981

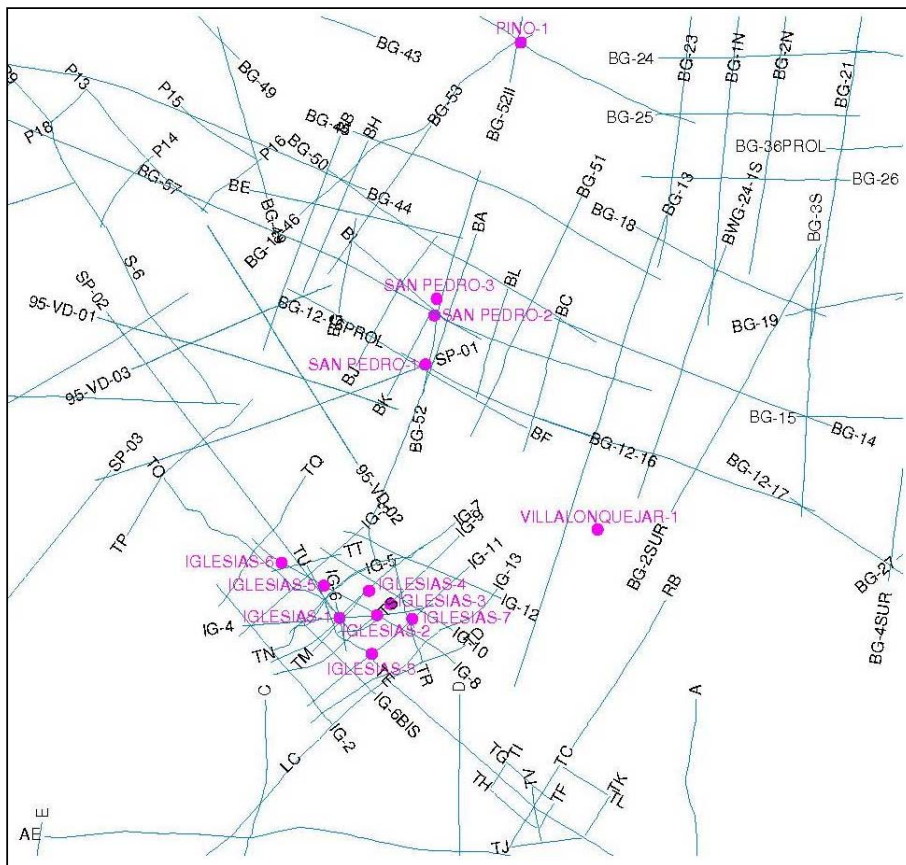
VILLALONQUEJAR-1

Encuadre geográfico y geológico

La zona de estudio se localiza al noroeste de Burgos, a unos 6 km, entorno al polígono industrial de Villaloncejar.

*Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.*





EXPLORATION



HC

- Campaña sísmica BG-12 realizada por AUXINI en **1975**.
- Campaña sísmica BG- realizada por AUXINI en **1976**.
- Campaña sísmica BGW-24 realizada por AUXINI en **1975**
- Sondeos : San Pedro-1, San Pedro-2, San Pedro-3 (**1960-1961**) e Iglesias-1 Valdebro (**1955**)

RW

- Campaña SP-92, líneas SP-1, SP-2 y SP-3 ENRESA (**1992**)

GSt

- Campaña sísmica IG (Enagas 1977)
- Sondeos: Iglesias 2 a 8 (Enagas 1978-1979)

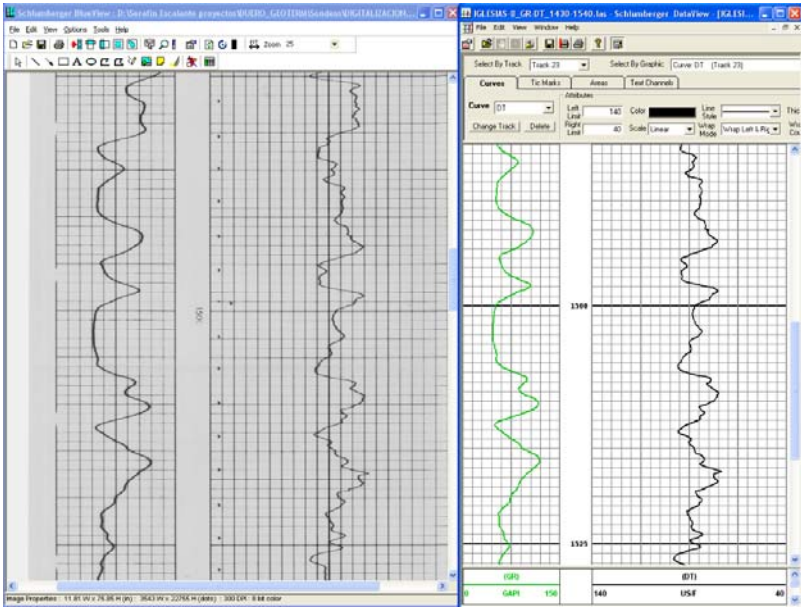
Gth

- Sondeo : Villalonguejar-1 Enadimsa (1981)

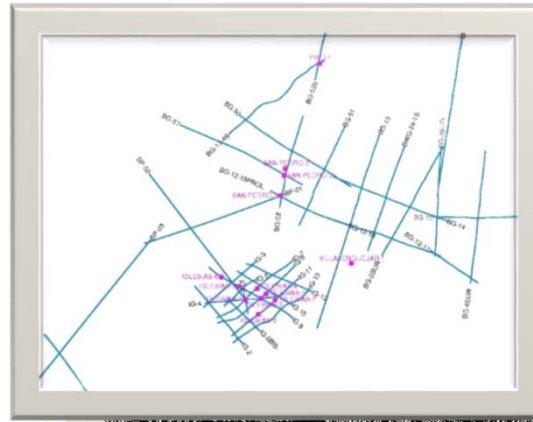
Recopilación de información pública y privada de sísmica y de sondeos

Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.

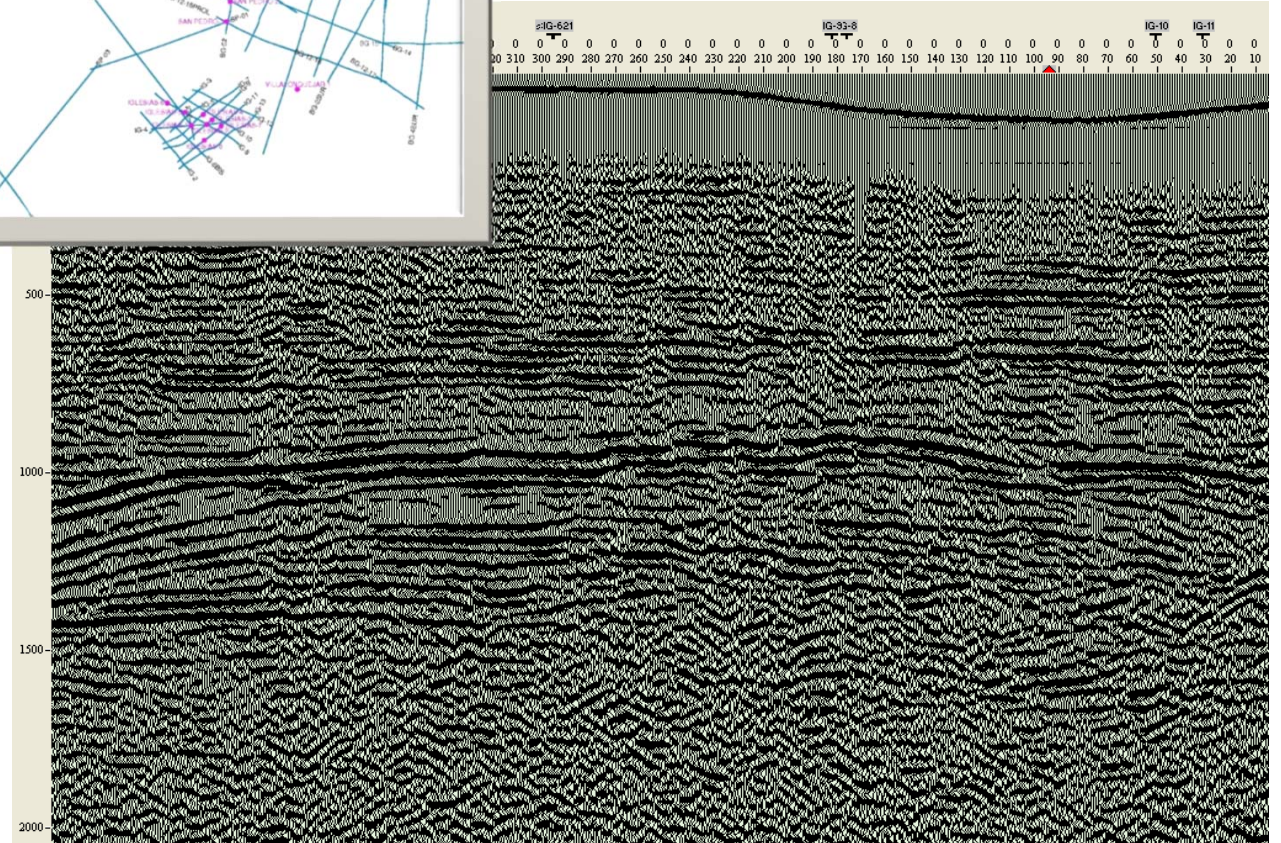




Sondeo digitalizado



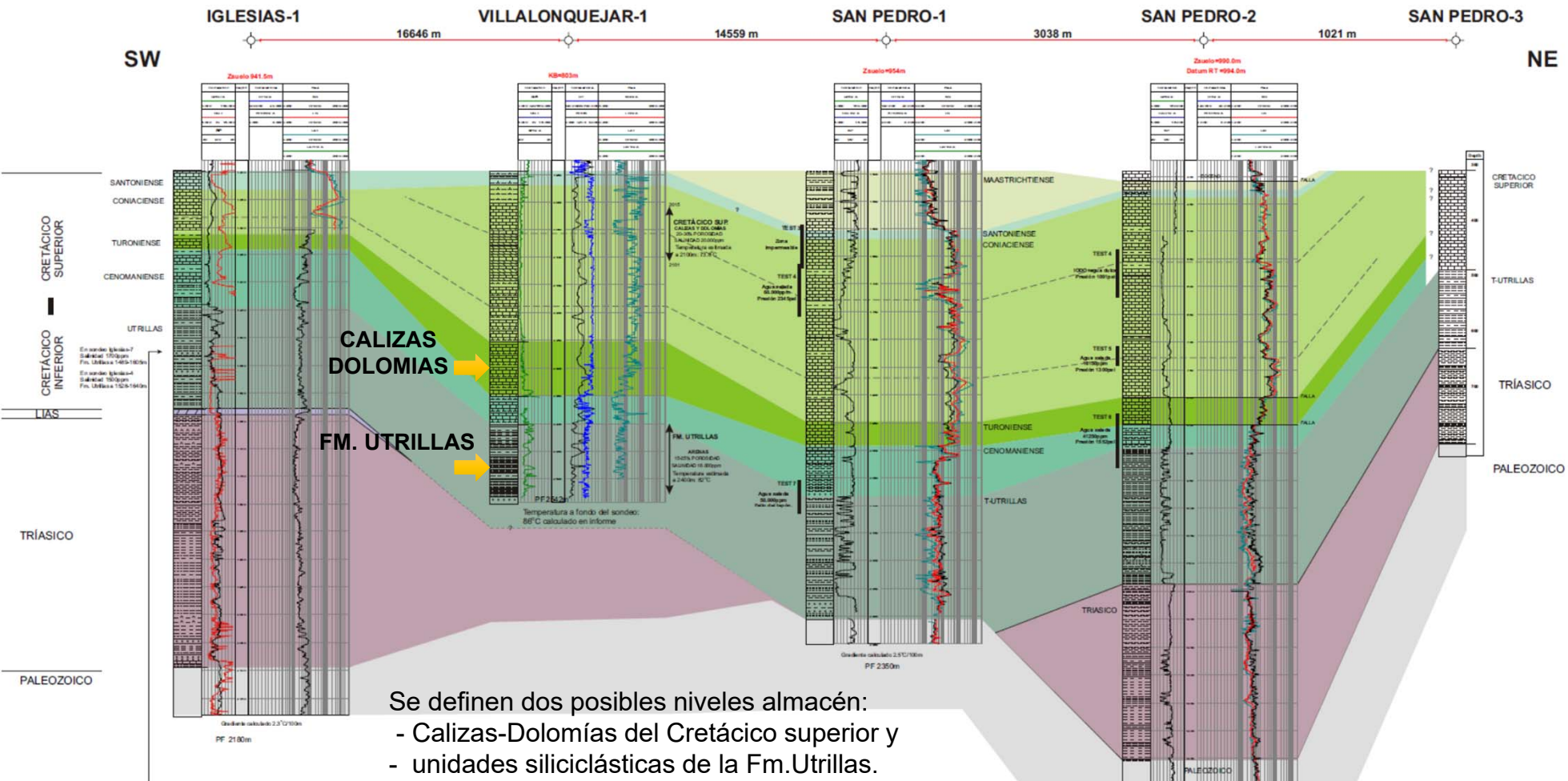
Perfil sísmico vectorizado, IG-4



Digitalización y vectorización

*Geophysical hydrocarbon exploration data and Deep Geothermal research:
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Correlación estratigráfica del mesozoico

Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.

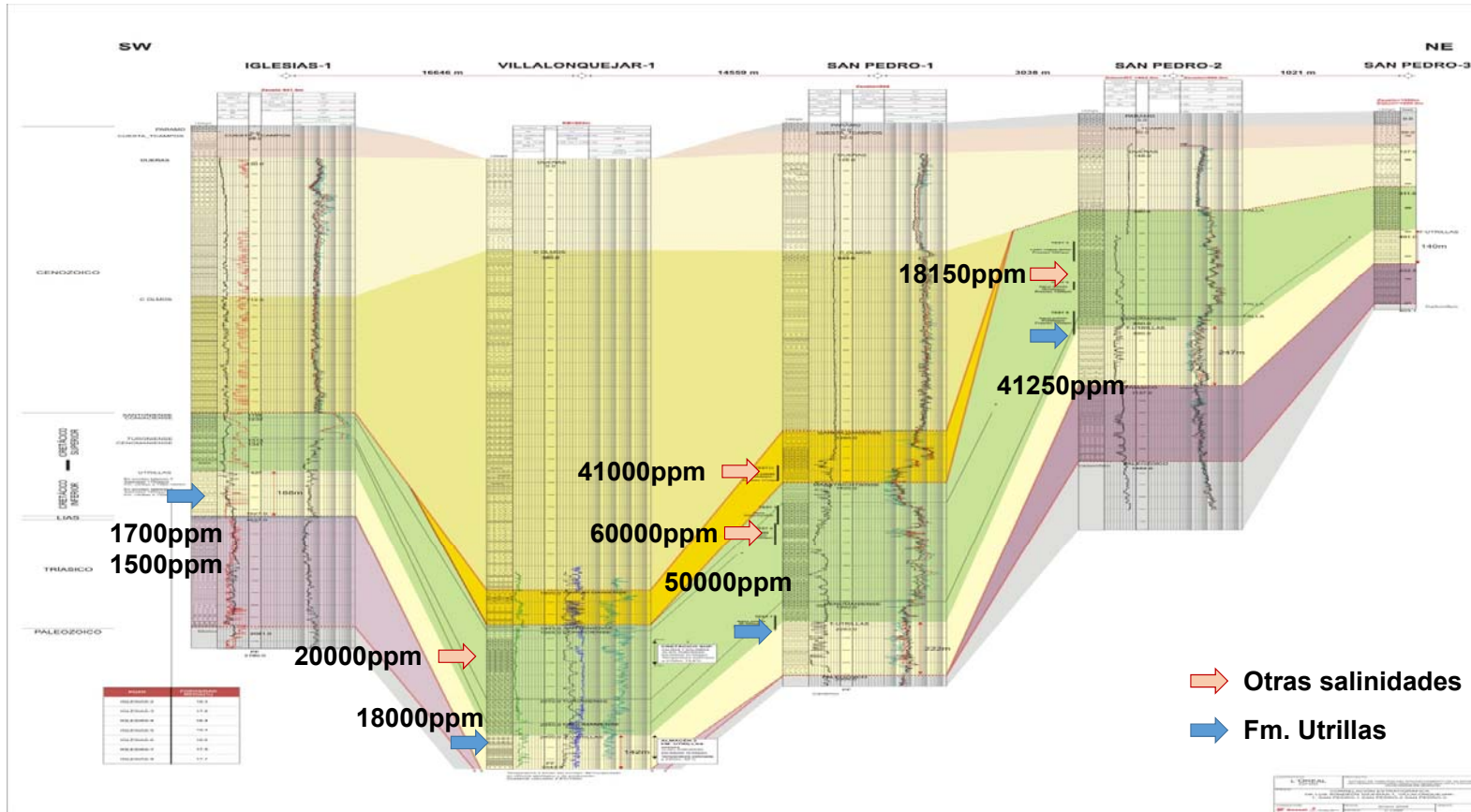
Gessal

Interreg
POCTEFA



DATOS DE SALINIDADES EN LA FM. UTRILLAS

SONDEOS	IGLESIAS-4	IGLESIAS-7	VILLALONQUEJAR-1	SAN PEDRO-1	SAN PEDRO-2
INTERVALO (m)	1497-1516	1489-1605	2400-2542	2070-2300	890-1140
SALINIDAD (ppm)	1500	1700	18000	50000	41250



Salinidades

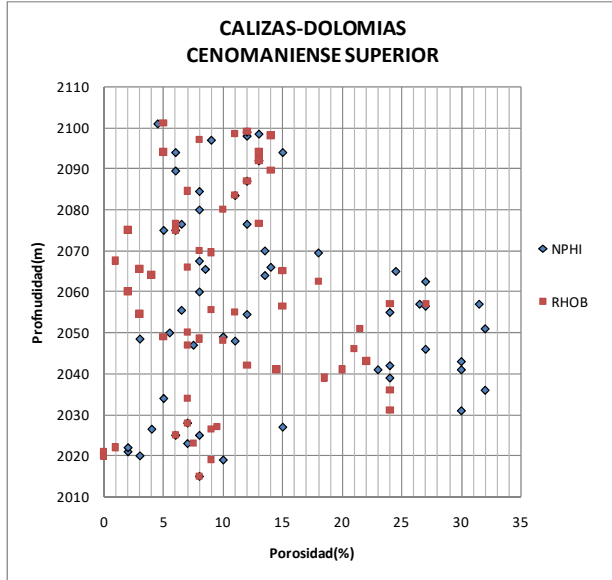
Geophysical hydrocarbon exploration data and Deep Geothermal research:
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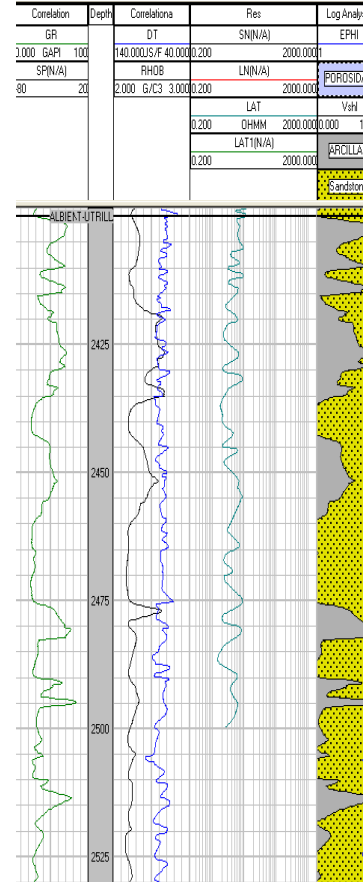
VILLALONQUEJAR-1:

POROSIDAD CENOMANIENSE:

CALIZAS Y DOLOMIAS CENOMANIENSES (2015-2107m)



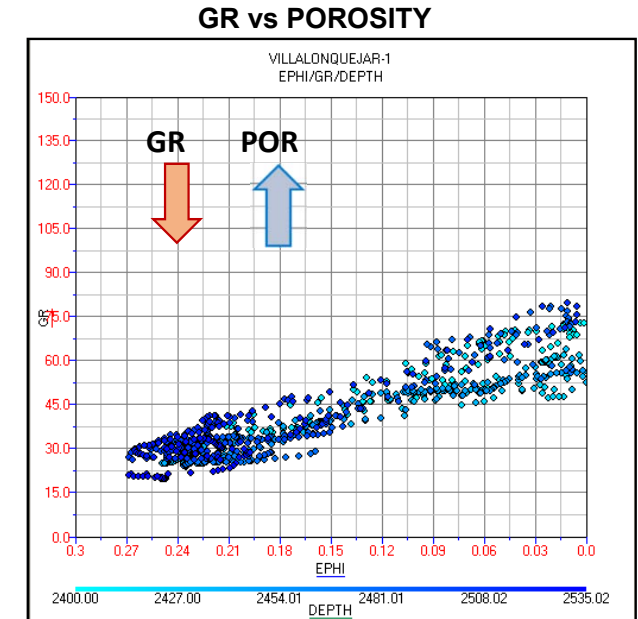
- Gran dispersión de valores.
- Valores anormalmente elevados para carbonatos (>15%).
- Formación posiblemente fracturada



POROSIDAD UTRILLAS:

A partir de las sondas sónica y neutrónica se ha estimado la porosidad efectiva de la Fm. Utrillas para el sondeo Villalonguejar-1

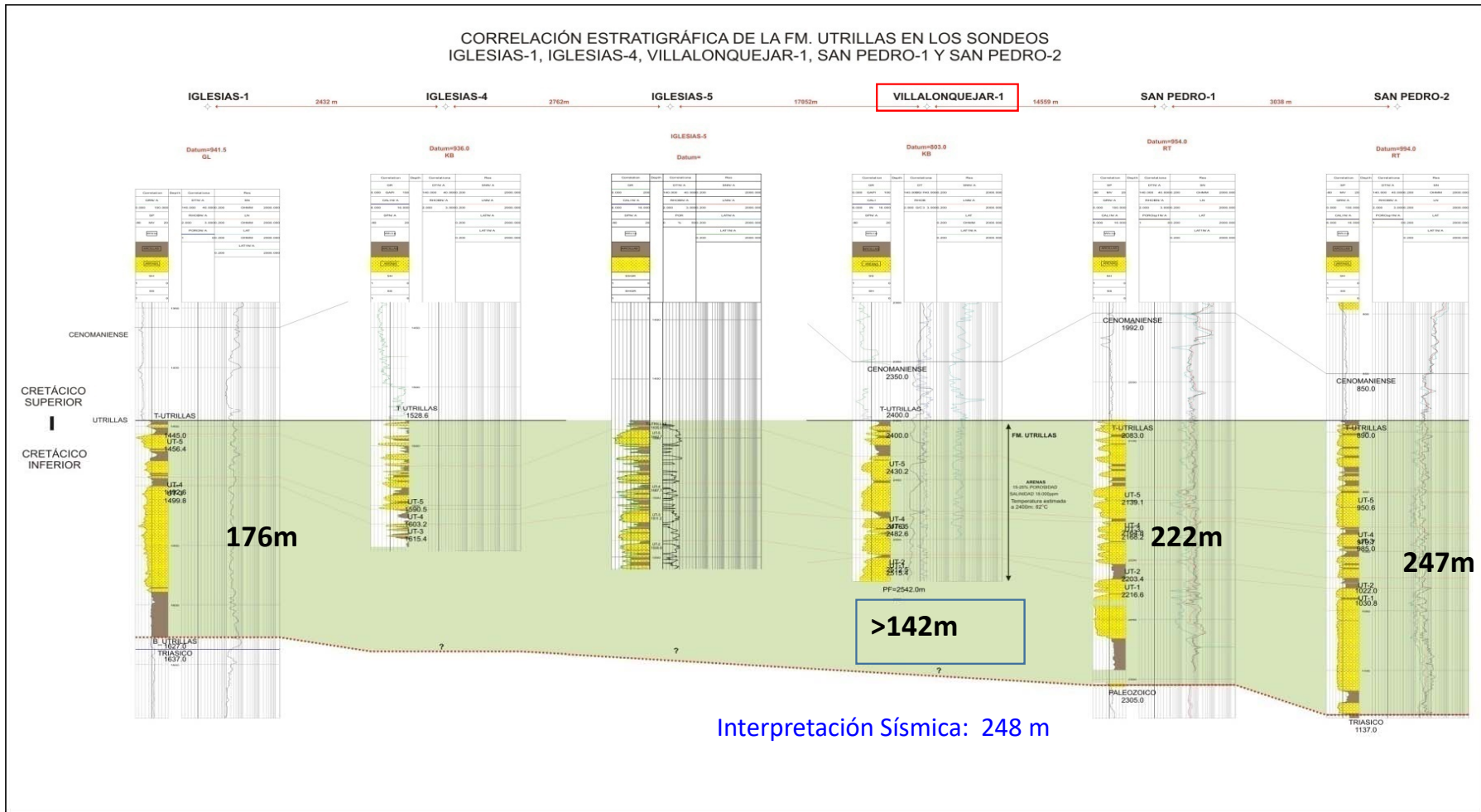
Porosidad promedio calculada: 16.8%



Análisis petrofísico del sondeo Villalonguejar-1

Geophysical hydrocarbon exploration data and Deep Geothermal research:
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CORRELACIÓN ESTRATIGRÁFICA DE LA FM. UTRILLAS EN LOS SONDEOS IGLESIAS-1, IGLESIAS-4, VILLALONQUEJAR-1, SAN PEDRO-1 Y SAN PEDRO-2

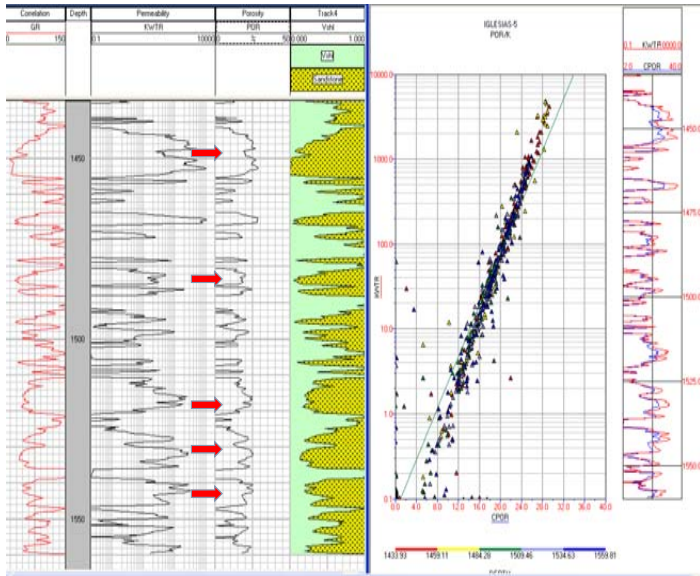


Correlación estratigráfica de la Fm.Utrillas

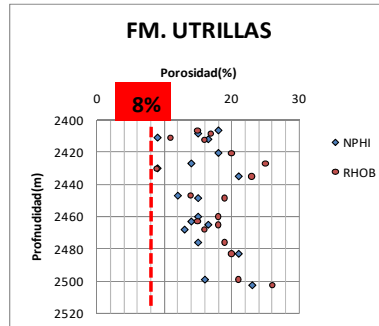
Geophysical hydrocarbon exploration data and Deep Geothermal research:
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PERMEABILIDAD UTRILLAS IGLESIAS-5:
Datos extraídos a partir de los logs de las diagráfías

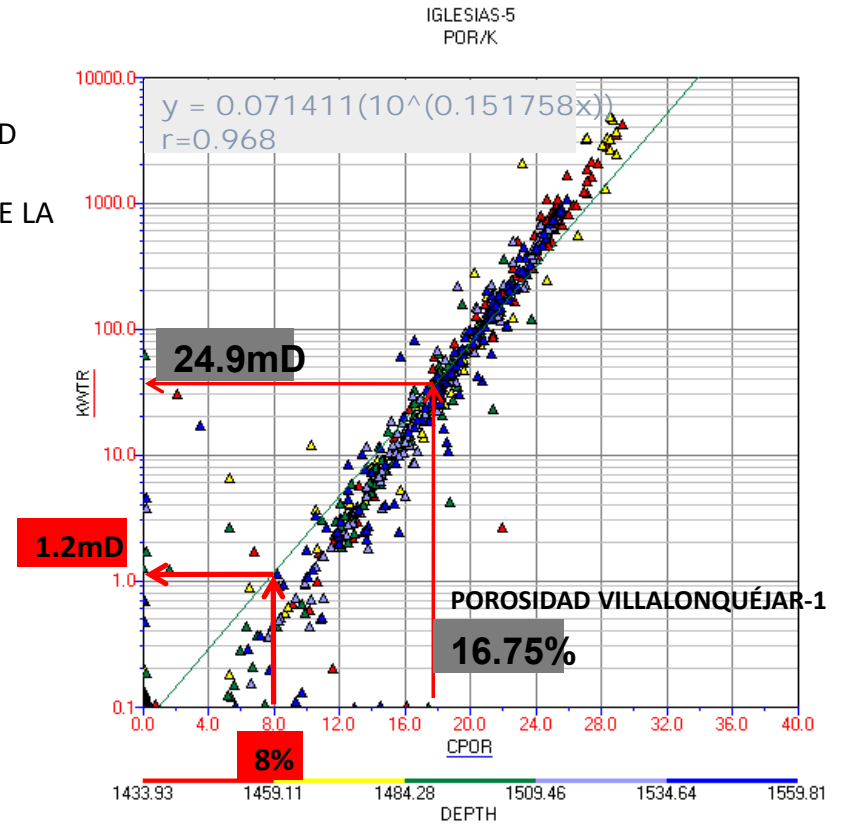


CÁLCULO DE LA PERMEABILIDAD TEÓRICA DEL SONDEO VILLALONQUÉJAR-1 A PARTIR DE LA RELACIÓN POROSIDAD-PERMEABILIDAD DEL SONDEO IGLESIAS-5.



PERMEABILIDAD UTRILLAS VILLALONQUEJAR-1:

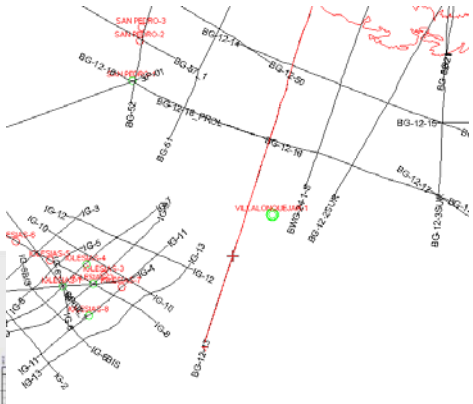
PERMEABILIDAD vs POROSIDAD



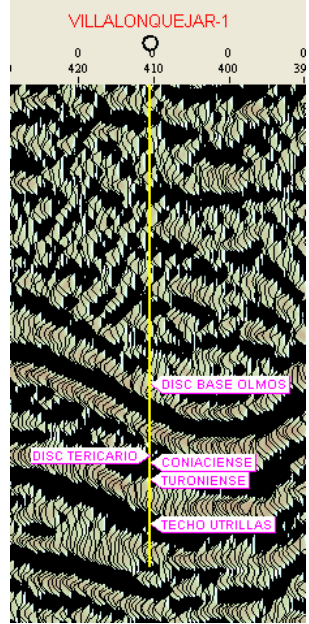
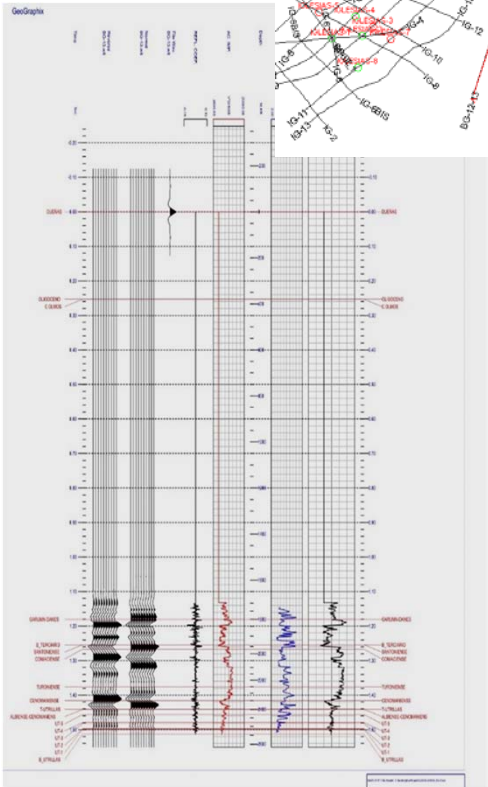
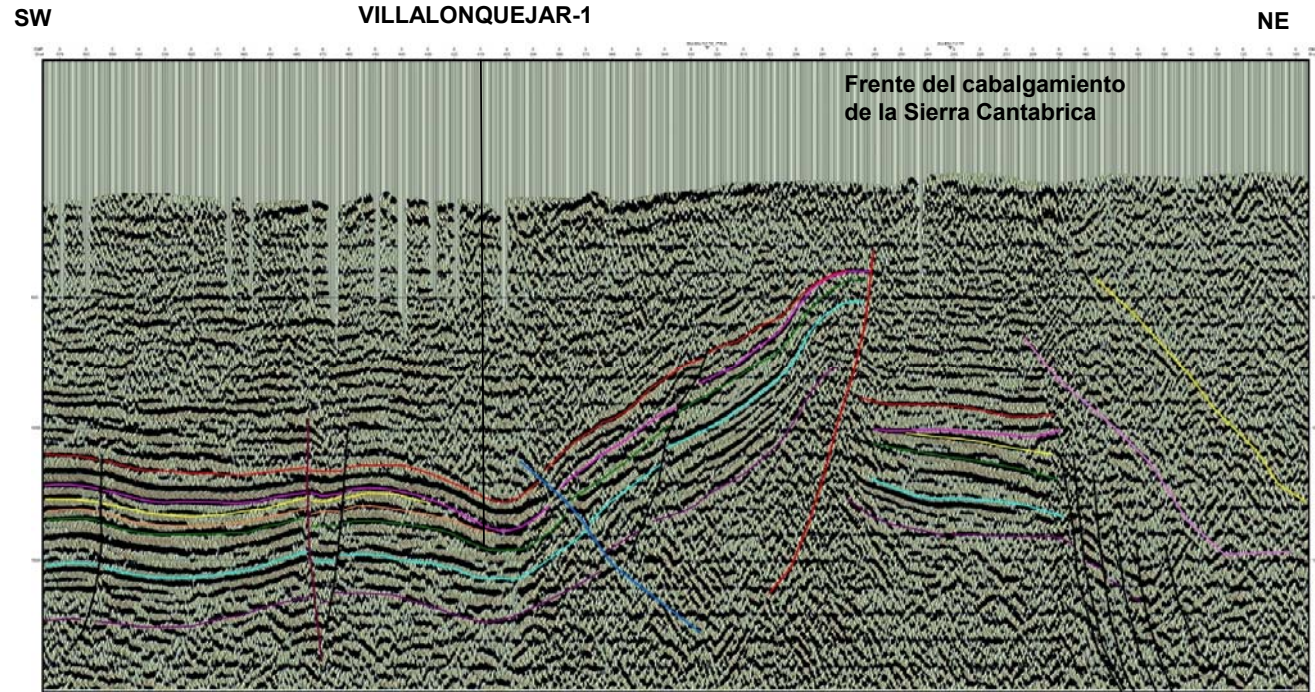
Permeabilidad de la Fm.Utrillas

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BG12-13

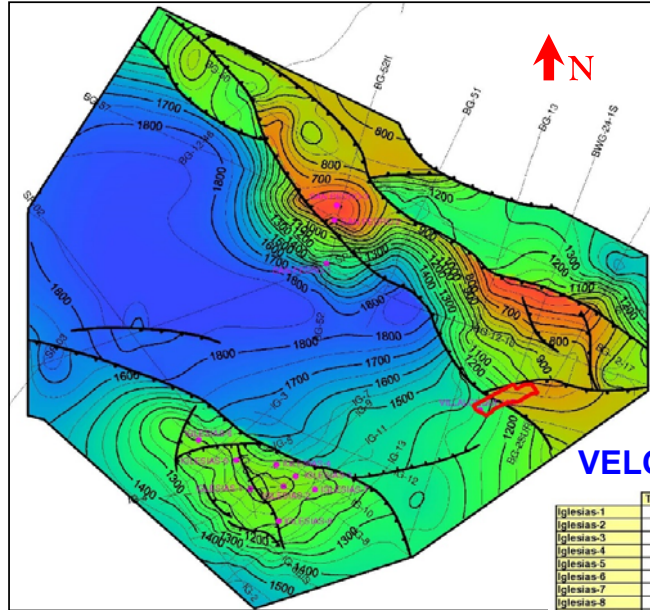


Geofísica: perfiles sísmicos

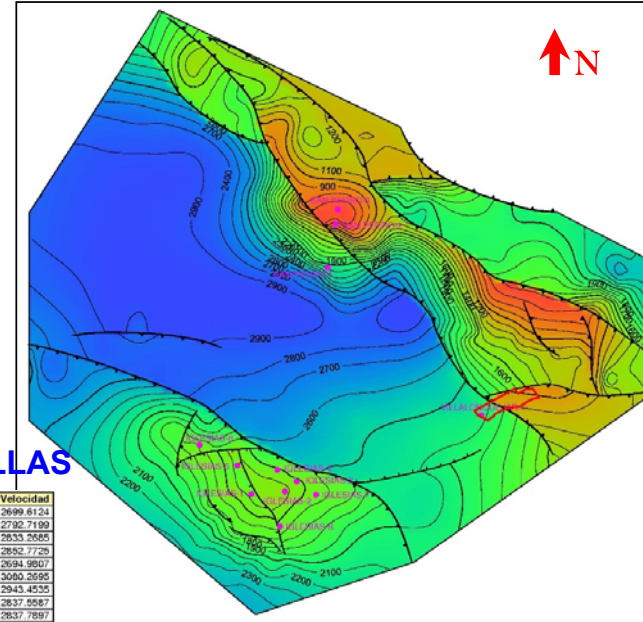
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ISOCRONAS TECHO UTRILLAS

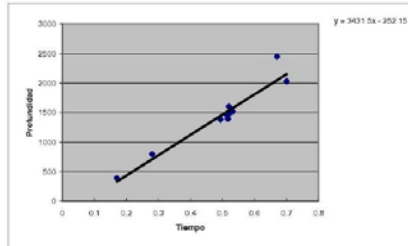


ISOBATAS TECHO UTRILLAS



VELOCIDADES TECHO UTRILLAS

	Tiempo TWT (sg)	Tiempo OWT (sg)	Profundidad (m)	Ecuacion	Desviacion	Velocidad
Iglesias-1	1.032	0.518	1393	1518.504	123.504	2699.6134
Iglesias-2	0.989	0.4945	1381	1444.7268	63.72675	2792.7190
Iglesias-3	1.028	0.514	1456.3	1511.641	55.341	2833.2685
Iglesias-4	1.046	0.523	1492	1542.6245	50.6245	2852.7728
Iglesias-5	1.036	0.518	1396	1525.367	129.367	2694.9807
Iglesias-6	1.039	0.5195	1400.2	1535.5143	-69.68575	3050.2635
Iglesias-7	1.054	0.527	1551.2	1556.2505	4.0505	2943.4535
Iglesias-8	1.065	0.5328	1511	1576.1238	64.12378	2837.6587
San Pedro-2	0.561	0.2805	796	710.38575	-85.61425	2837.7897
San Pedro-3	0.342	0.171	391	334.6365	-56.3635	2286.5497
San Pedro-1	1.4	0.7	2030	2149.9	119.9	2900
Villalonquejar-1	1.339	0.6695	2447	2045.2390	-401.76075	3654.9664



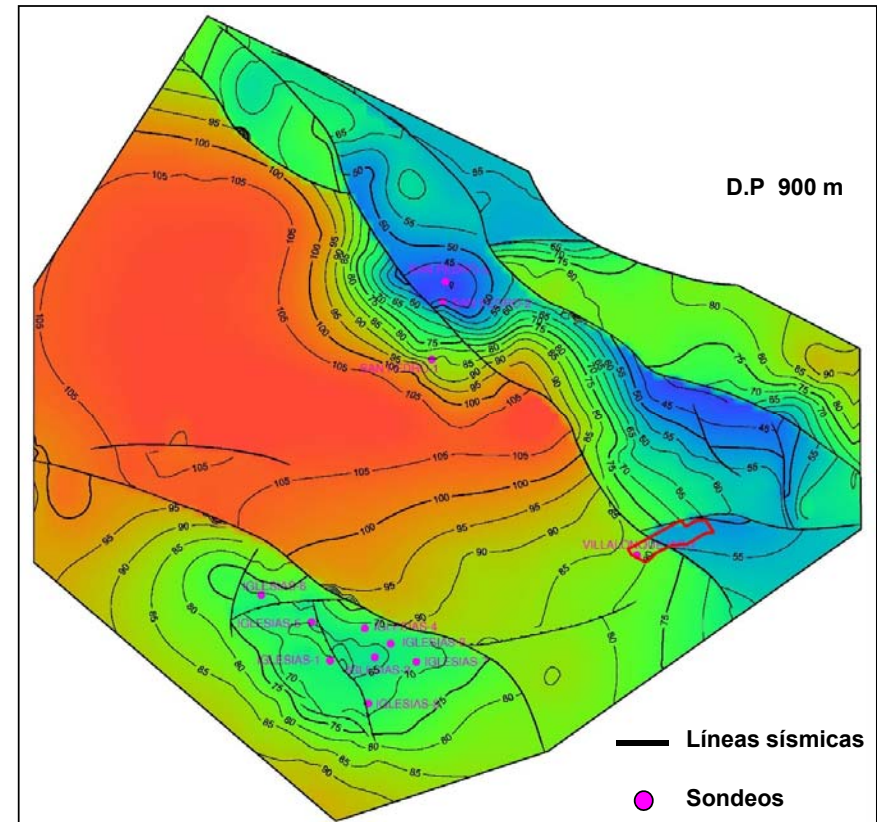
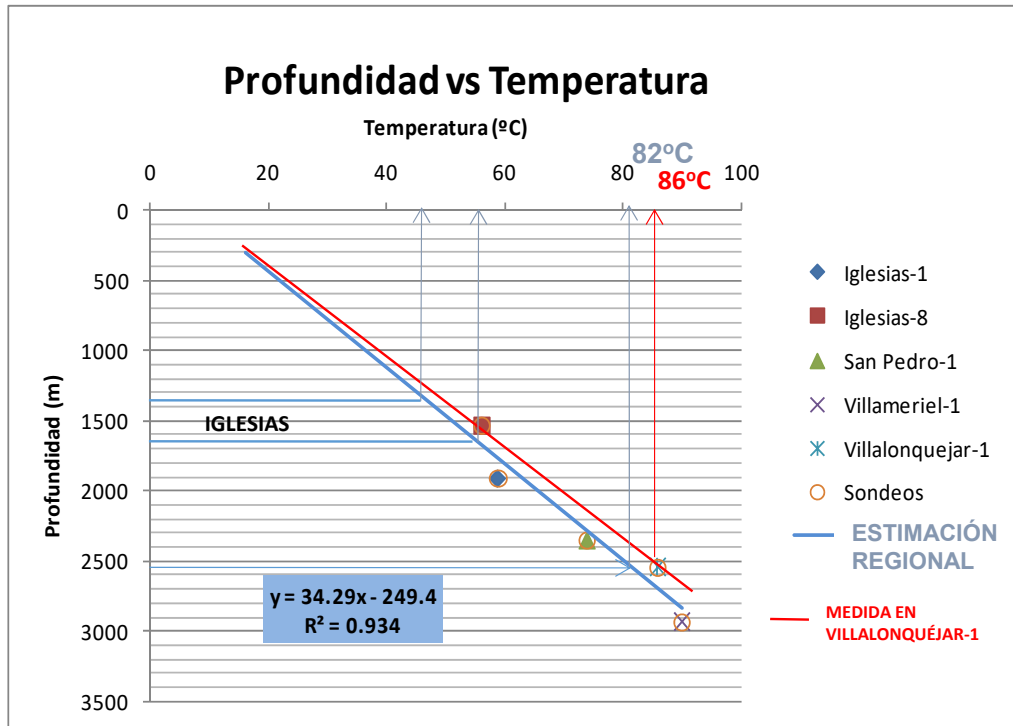
D.P: 900 m
Vreemplazamiento: 4000 m/sg

D.P 900 m

- Líneas sísmicas
- Sondeos
- ┌└ Falla normal
- └┌ Falla inversa
- ▭ Polígono industrial

Geofísica: mapas de isócronas/isobatas de la Fm. Utrillas

Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.

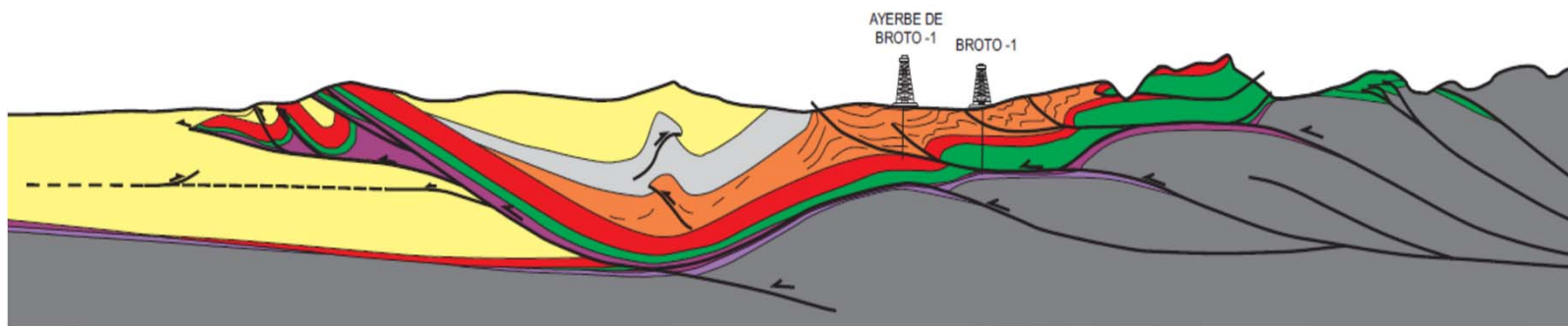
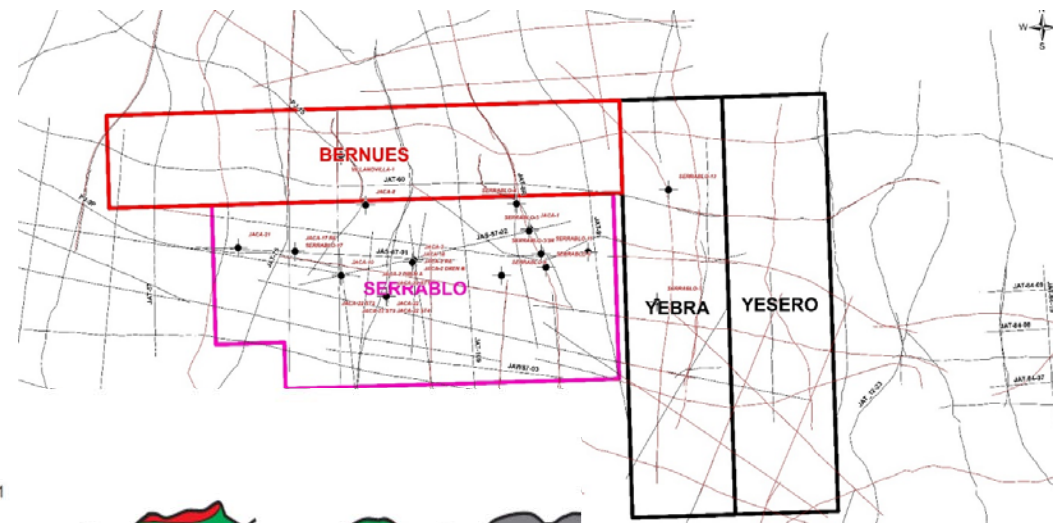


(2,3-2,67° in Iglesias area and 2,8° in Villalonquejar area.)

Gradiente térmico

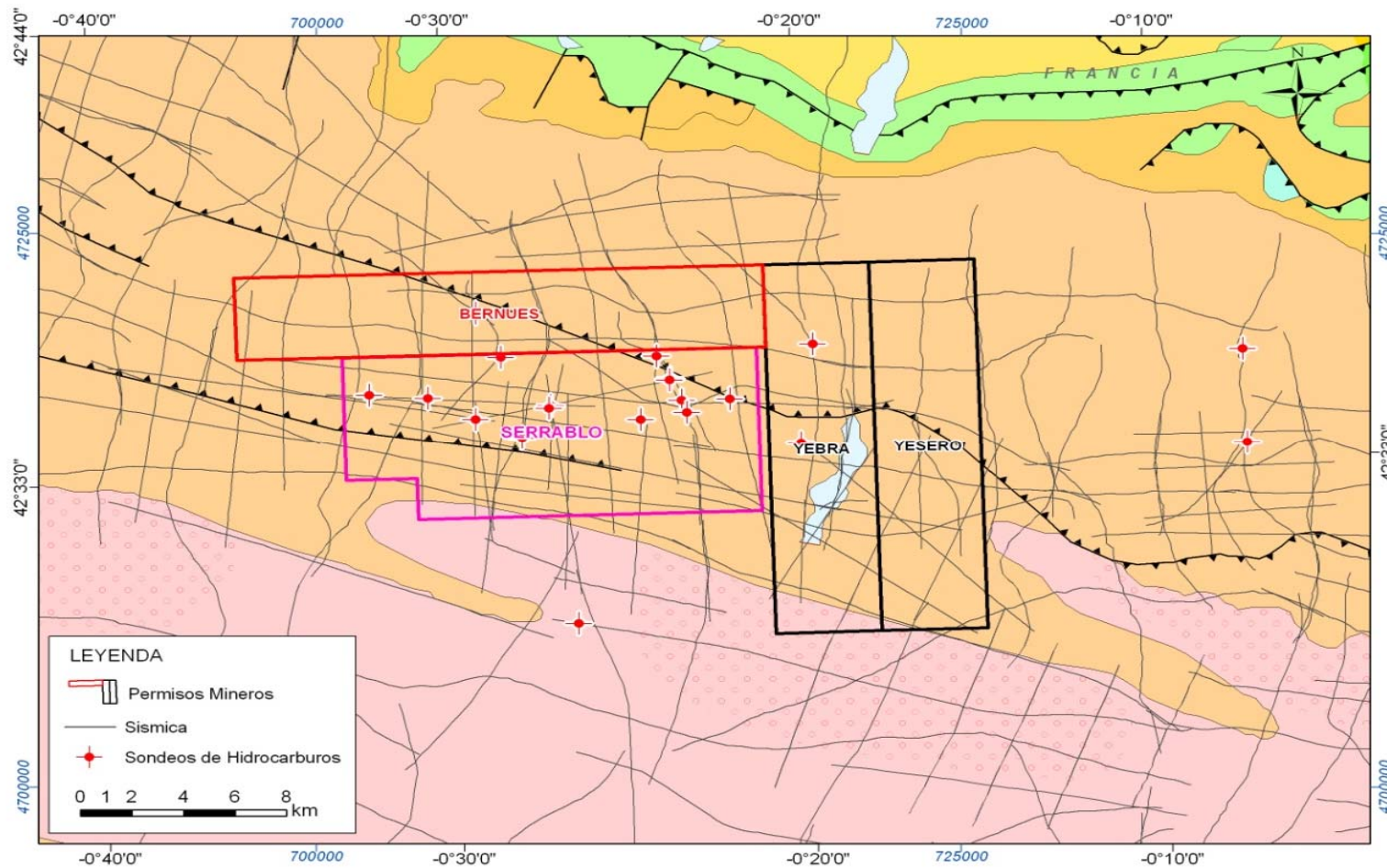
Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.

PROYECTO SERRABLO HUESCA



*Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.*



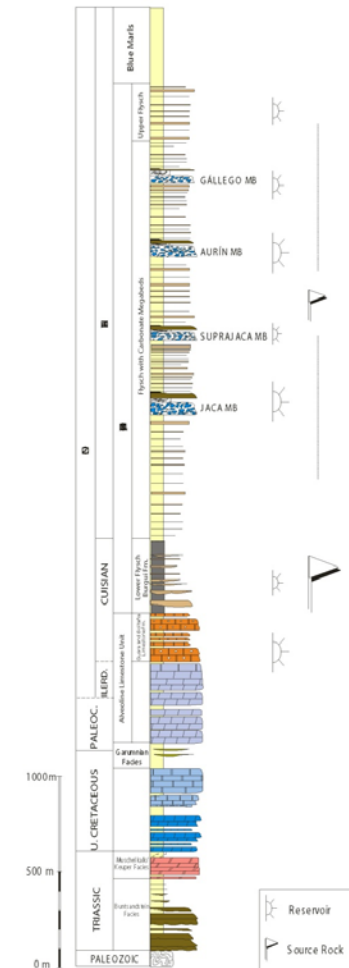
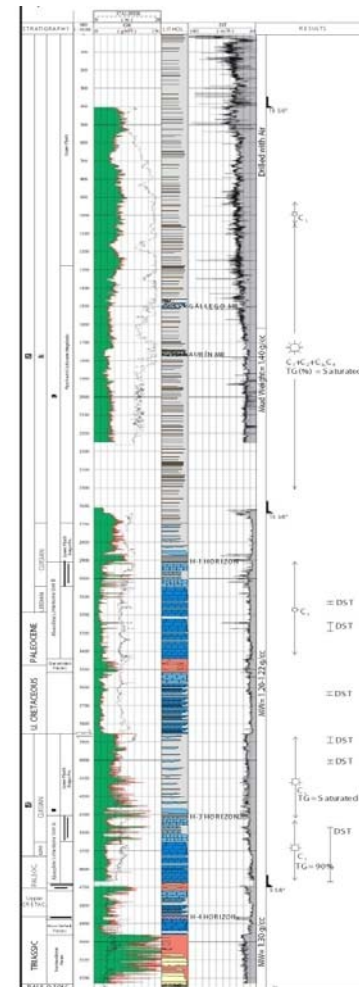
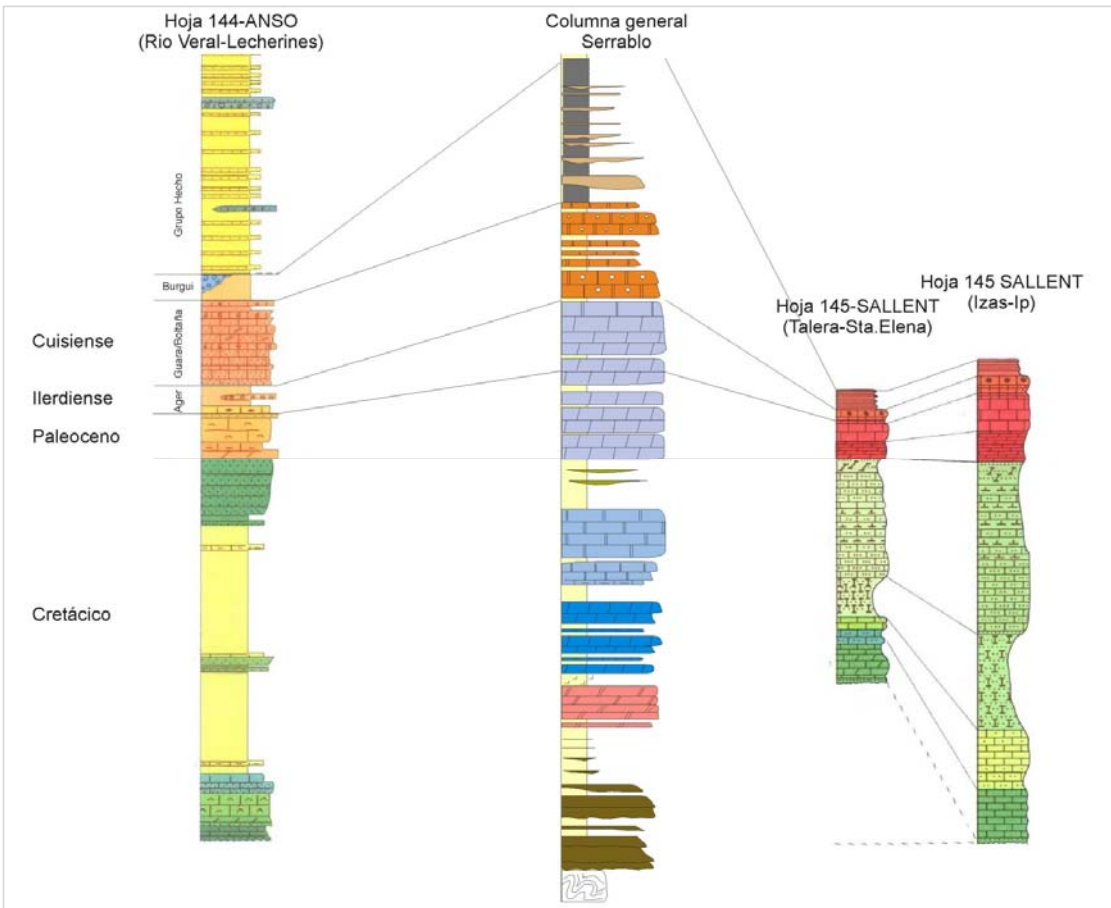


Mapa de posición de los perfiles sísmicos

Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.



Serrablo -1 (Eniepsa 1978)

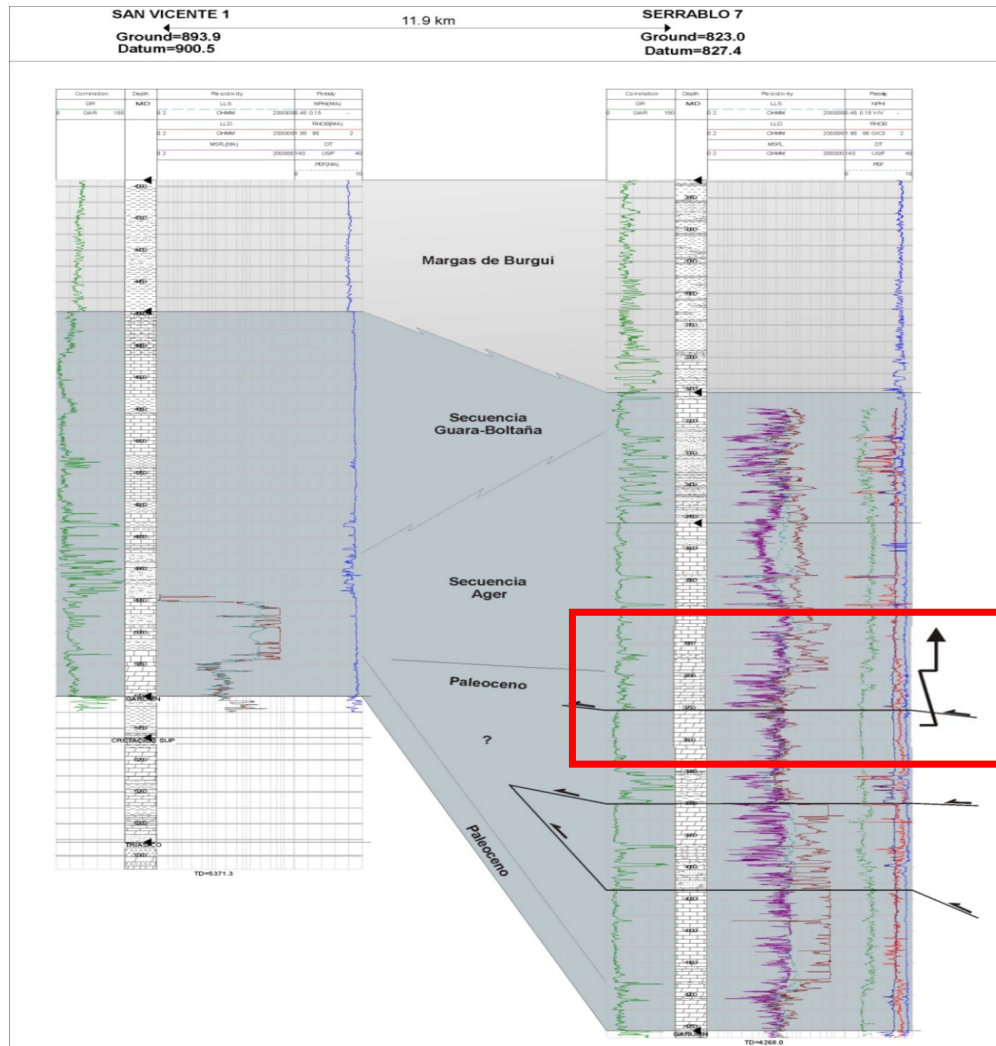


Correlación estratigráfica

Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.



S



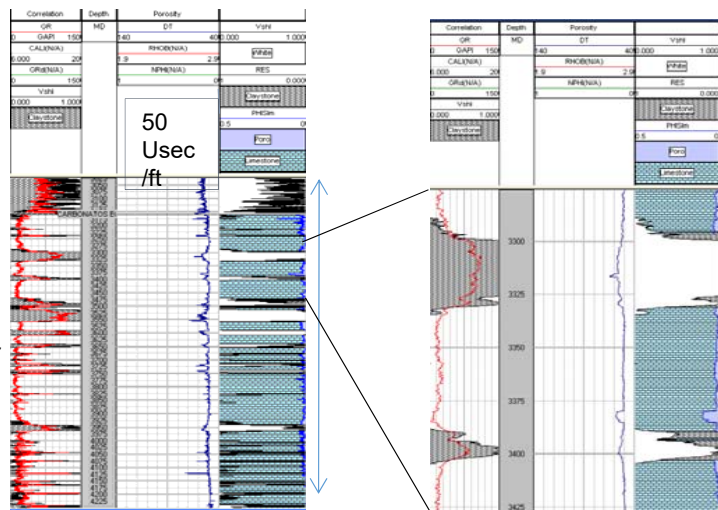
N

Acuifero Termal
3660-3850
125-150°
1000-2000 ppm

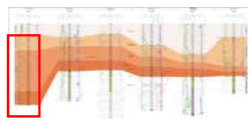
Geophysical hydrocarbon exploration data and Deep Geothermal research:
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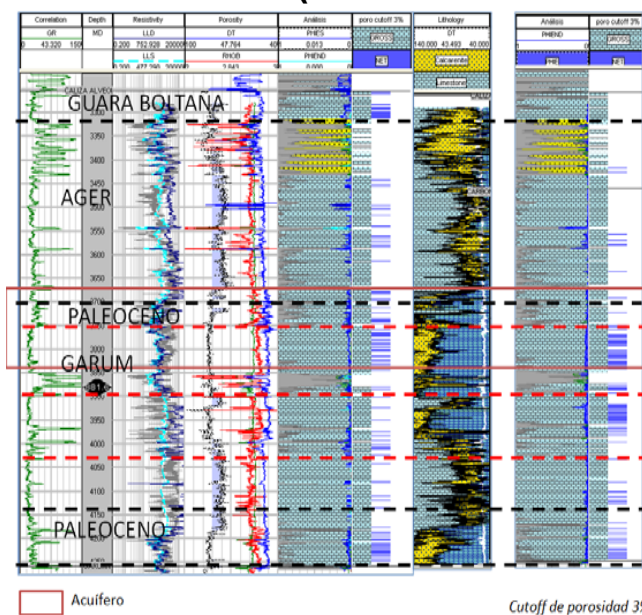
Sondeo Villanovilla-1 (Tramo carbonatado Eoceno)



Dt con valores muy bajos (50 Us/ft) lo que implica porosidad matricial muy baja.
 La porosidad sónica media es de 2%
 En tramos con matriz dolomítica puede alcanzar el 7%.
 El aspecto de la diagraña sónica parece indicar la presencia de niveles fracturados.



Sondeo Serrablo-7 (Tramo carbonatado Paleógeno)

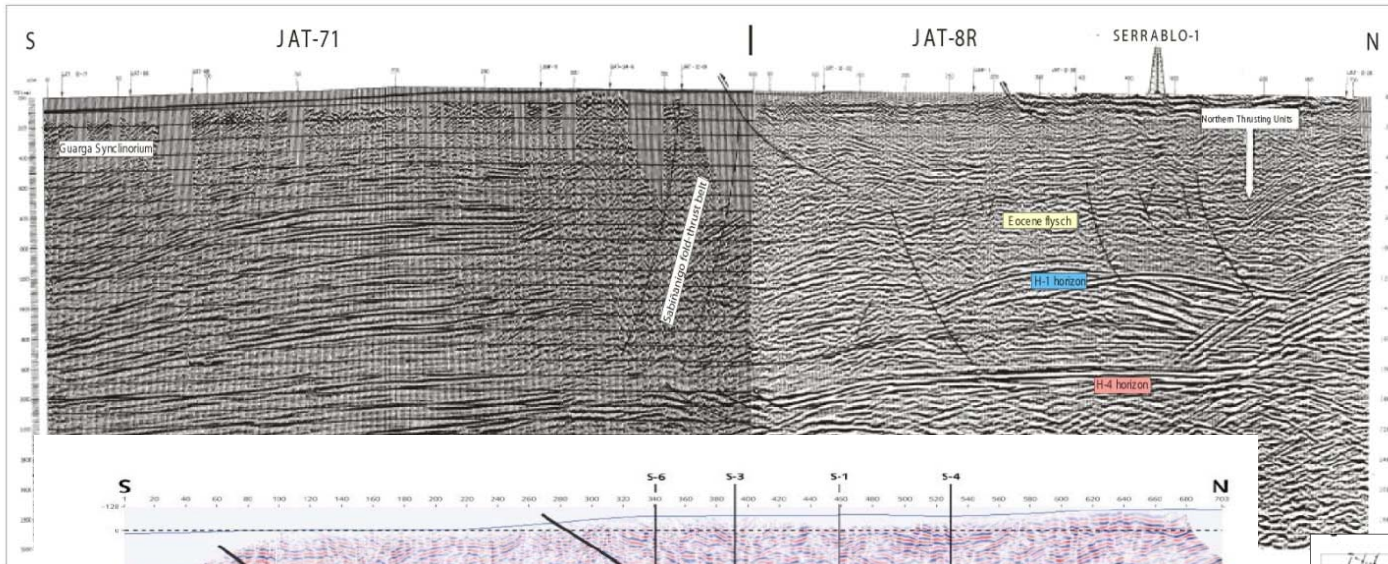


- Acuífero Termal**
- :3660-3850m
 - 190m
 - 1000-2000ppm
 - T° 125-150°

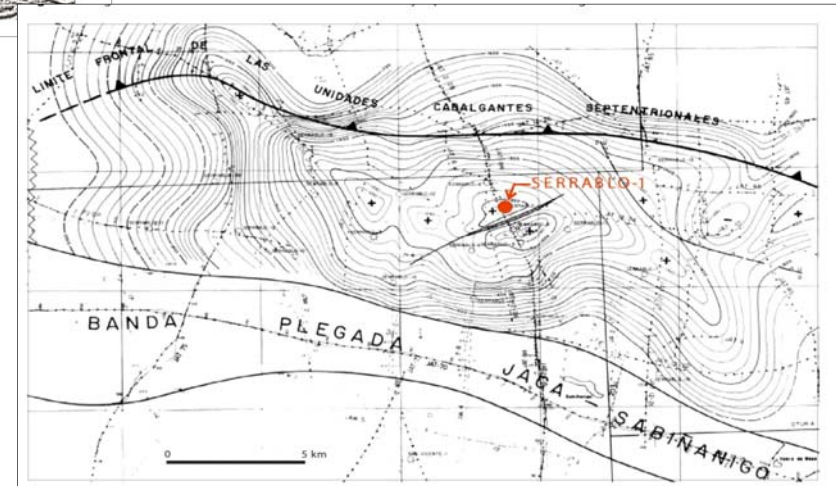
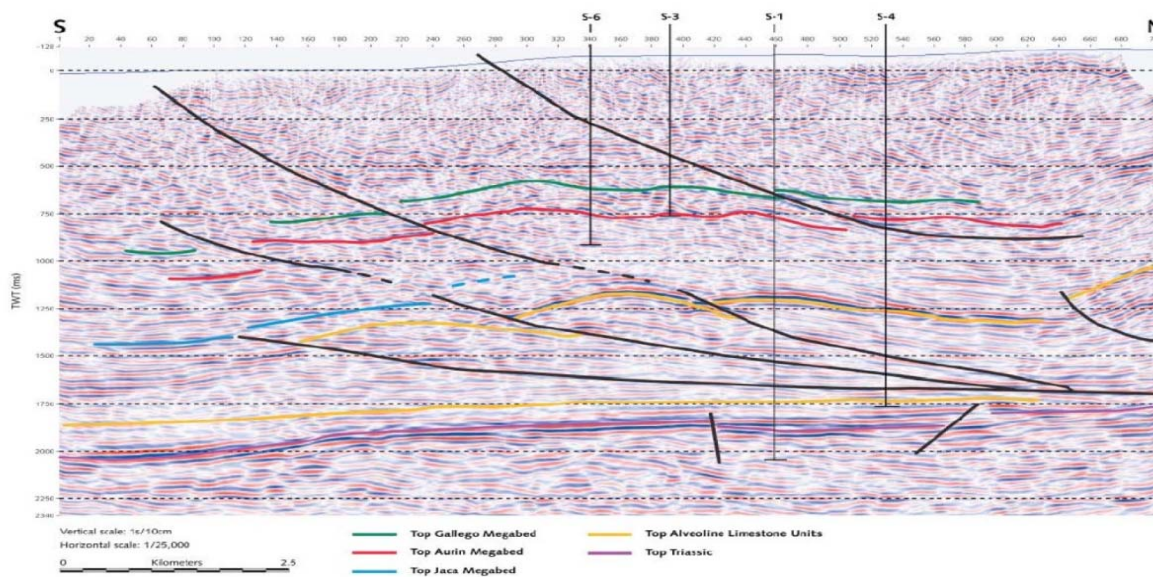
Análisis petrofísico

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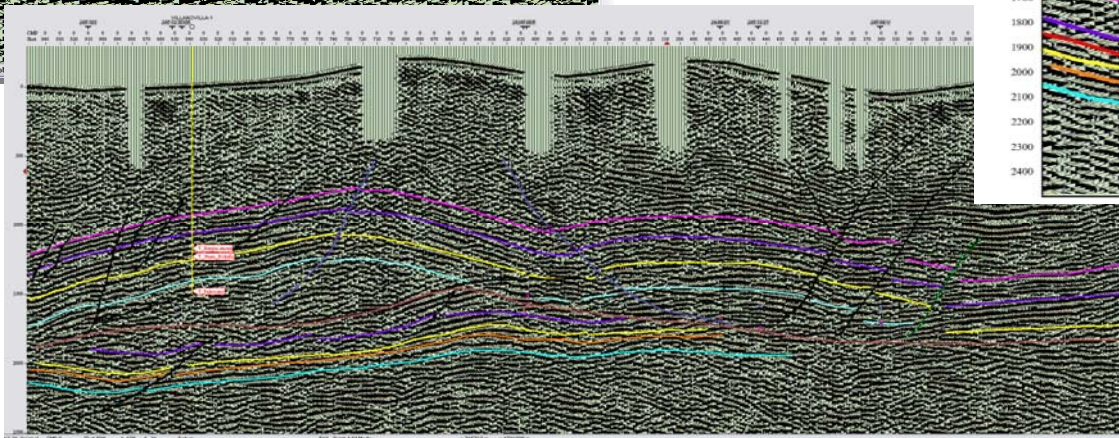
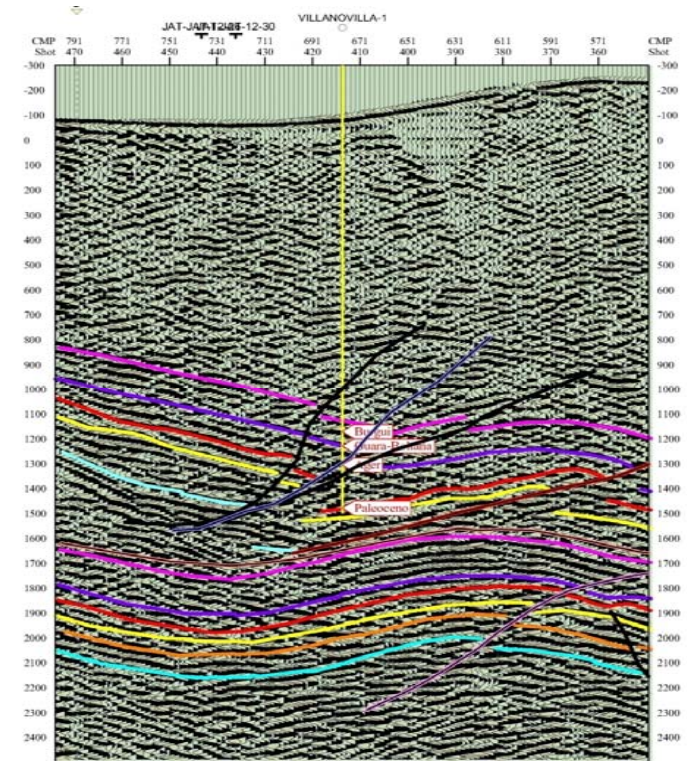
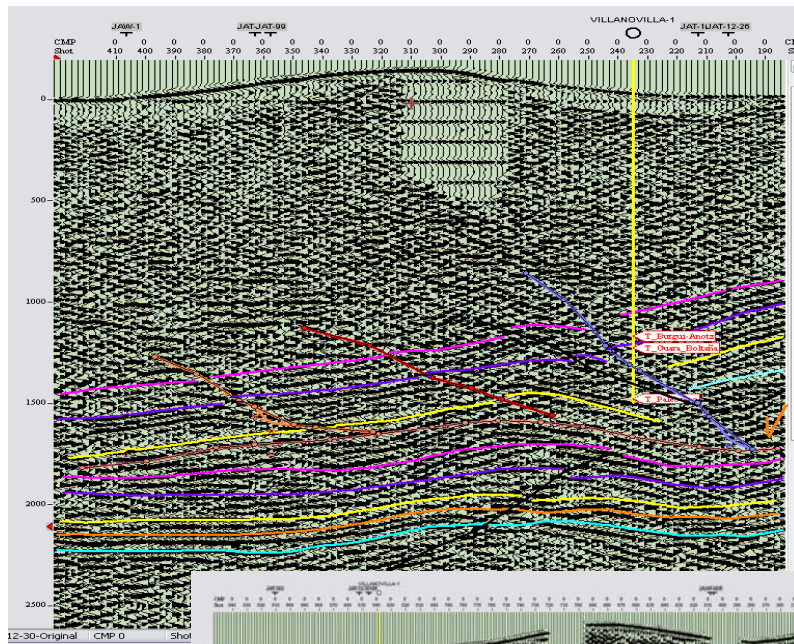
AGGEP 25 Aniversario
“ Serrablo field, a commercial gas
discovery in the Jaca basin
(southern Pyrenees, Spain”



Interpretación sísmica Antecedentes

*Geophysical hydrocarbon exploration data and Deep Geothermal research:
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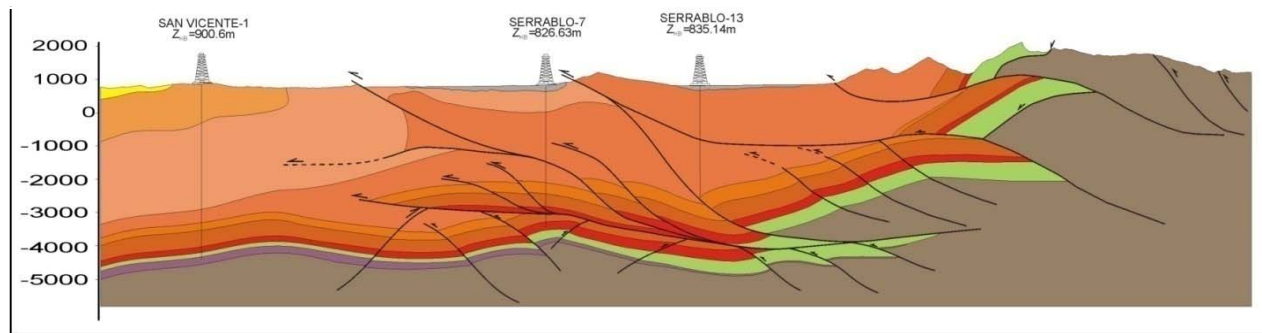
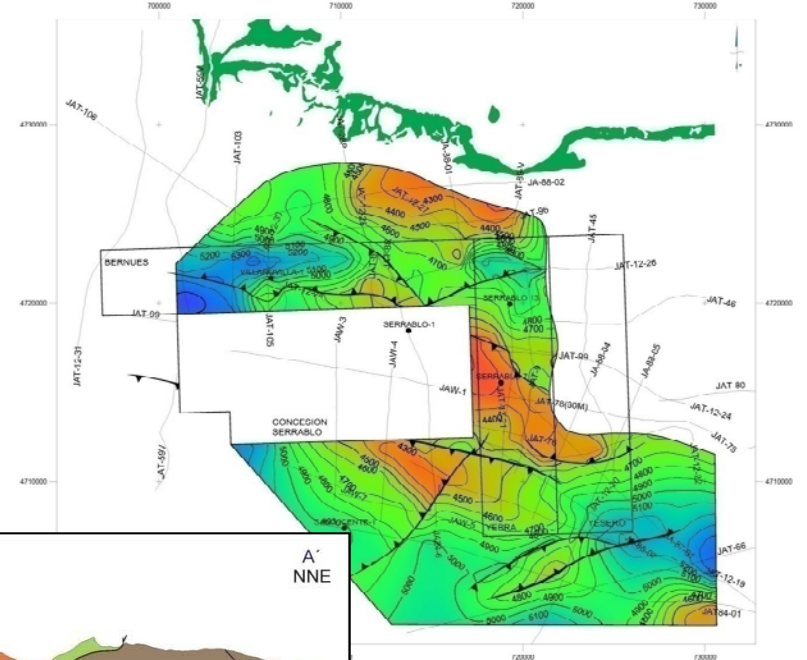
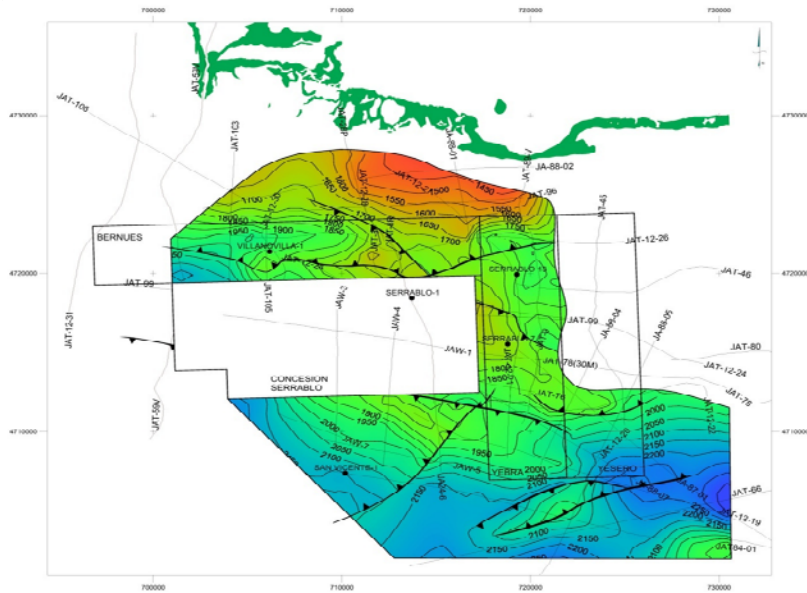
Interpretación sísmica

Geophysical hydrocarbon exploration data and Deep Geothermal research:
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ISOCRONAS CARBONATOS DEL PALEOCENO AUTOCTONO

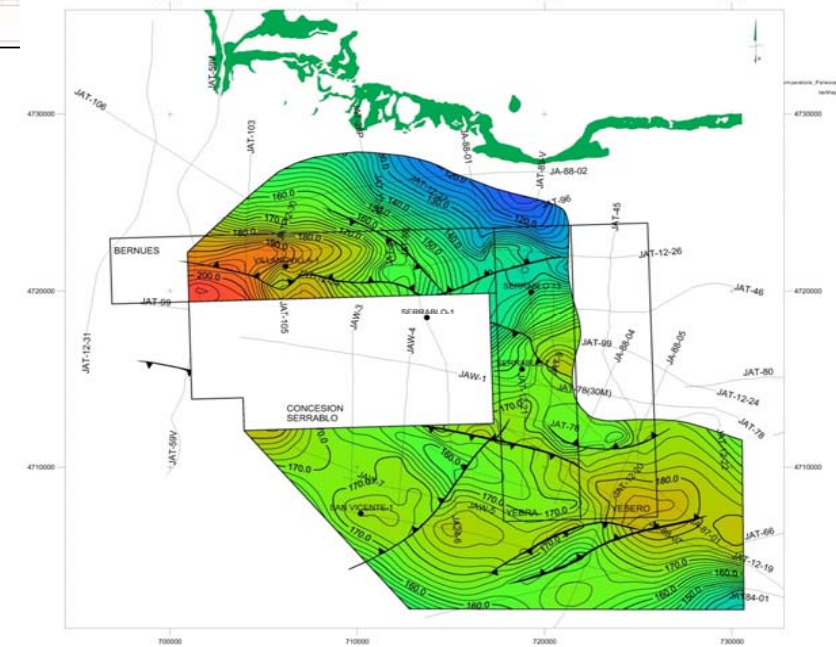
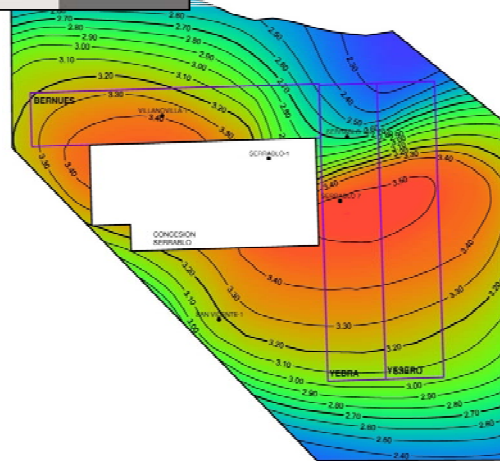
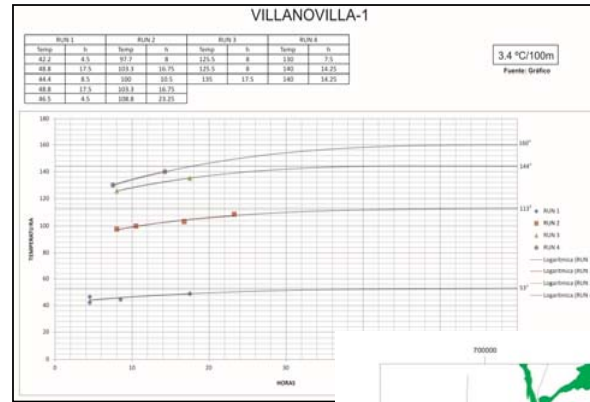
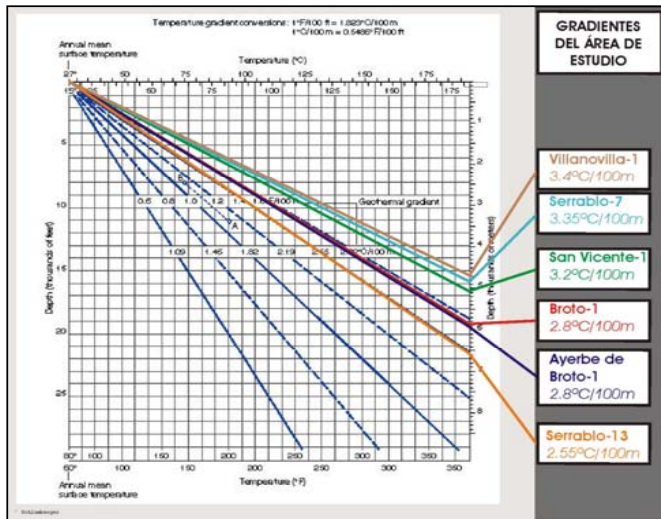
ISOBATAS CARBONATOS DEL PALEOCENO AUTOCTONO



Equidistancia: 50 ms
D.P : 900 m

Mapas estructurales (time/depth)

Geophysical hydrocarbon exploration data and Deep Geothermal research:
Two geothermal feasibility projects in Spain.



Gradiente térmico

Mapa de Temperaturas para el Techo del Paleoceno Autóctono

Geophysical hydrocarbon exploration data and Deep Geothermal research:
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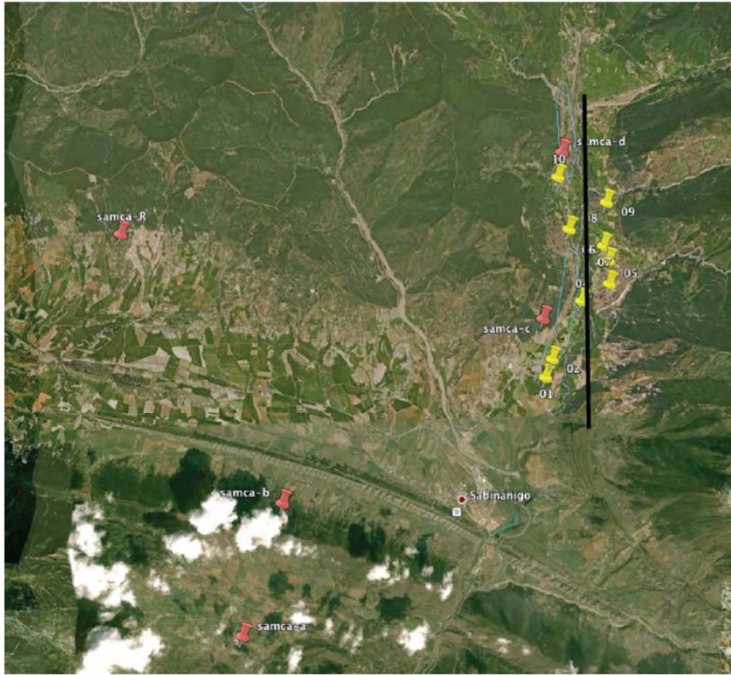


Figura 5: Localización de los sondeos magnetotelúricos realizados, en rojo los correspondientes a la campaña de Marzo de 2010 y en amarillo los de Mayo-Junio de 2010. Línea negra perfil sobre el que se han proyectado las estaciones para generar el modelo 2D de resistividades

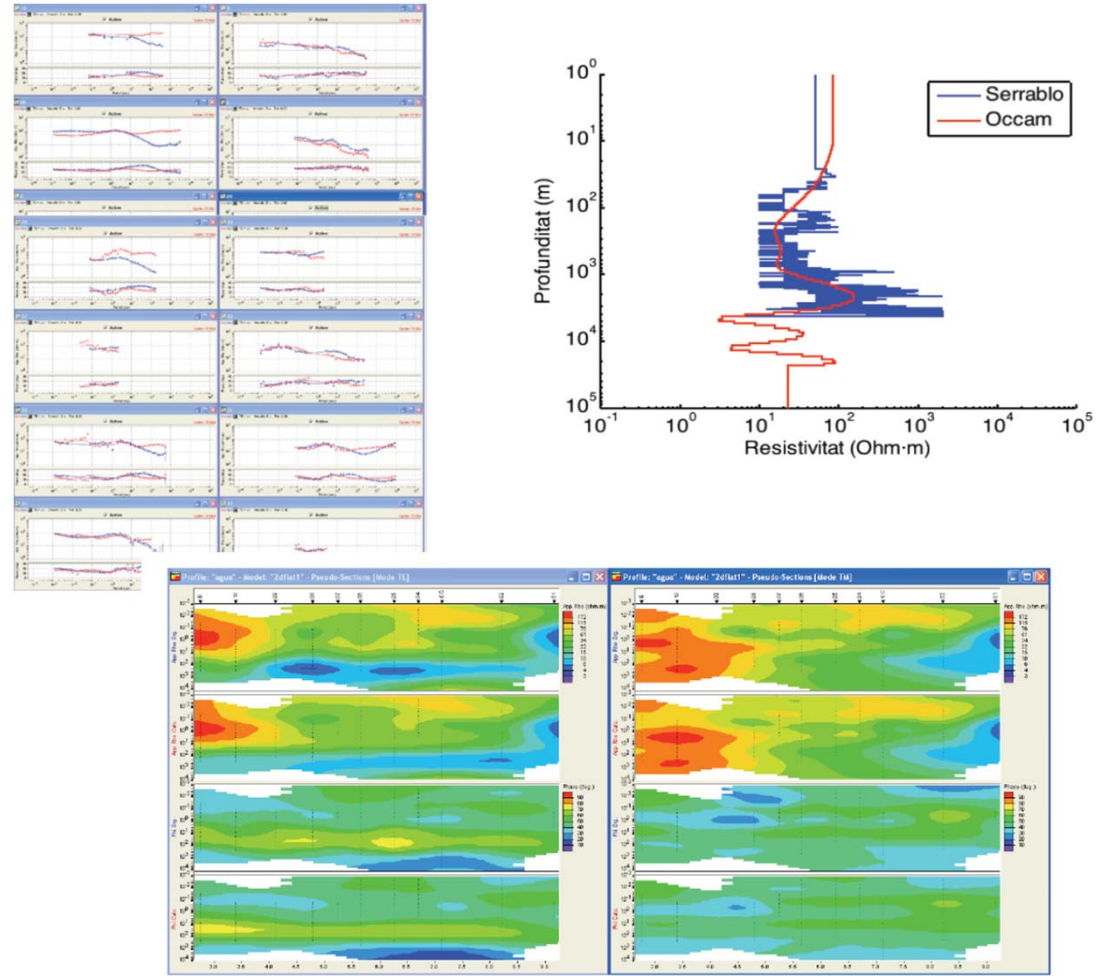


Figura 8: Comparación entre los datos registrados y la respuesta del modelo. Izquierda modo TM, derecha modo TE

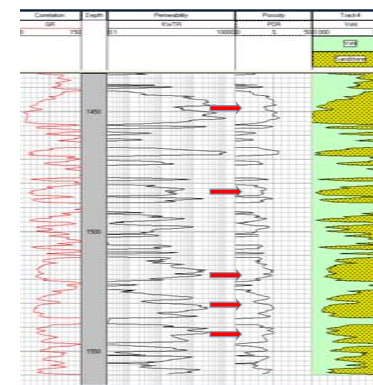
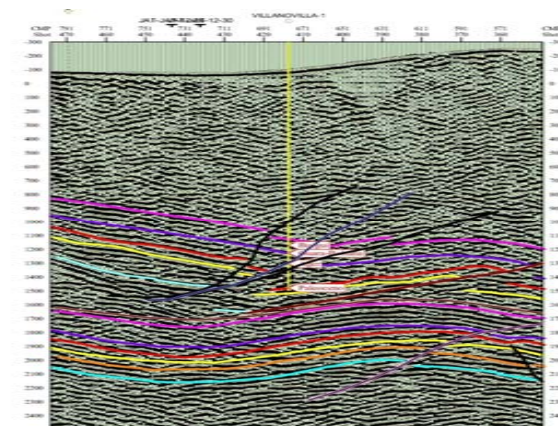
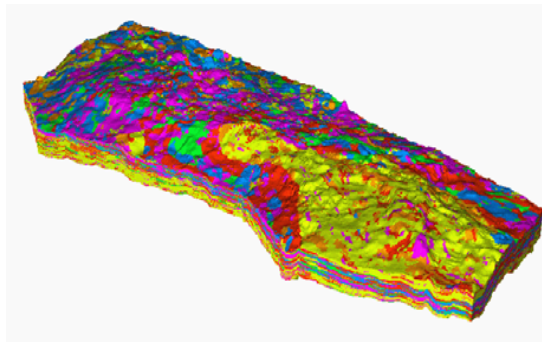
Prospección Magneto-Telúrica

Geophysical hydrocarbon exploration data and Deep Geothermal research:
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Conclusiones

- Any geothermal Project need an **exhaustive analysis of the geological and geophysical subsurface data**
- All the information should be integrated with **technical rigour**
- The **complexity of the geological domain** (stratigraphy, structure, petrophysics, etc) can not be simplified in a plain model
- The final geothermal production model will be directly committed by knowledge acquired based on the **quality of the Geological and Geophysical data**





THANK YOU FOR YOUR ATTENTION

juanklimowitz@gessal.com

C/ Toronga 21 Madrid 28043

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