

Towards 3D databases and harmonized 3D models at IGME-CSIC

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¹CN IGME-CSIC

November 22, 2022

Abstract

IGME-CSIC has a highly relevant geological and geophysical database that includes a continuous digital geological cartography at 1:50000; 1:200000 and 1:1000000 scales and a fair amount of geophysical data: gravity, magnetic, well-logs in tiff and LAS format, seismic lines in tiff and SEG-Y format, borehole and petrophysical data, together with other geophysical and geological studies. Since the 2004, an important effort has been done to undertake 3D geological and geophysical modelling ranging from local studies (mineral exploration or CO₂ storage sites) to regional geology for a better understanding of the subsurface structure and its geodynamic evolution as a base for other studies on natural hazards or mineral resources. These studies were “stand alone” and now IGME is designing a new strategy. It includes the available data and models harmonization (stratigraphy sequences, structural interpretations, faults distribution, seismic velocity models, spatial distribution of physical properties such as density and magnetic susceptibility, workflows, methodologies, evaluation of uncertainties, visualization, etc.) to comply with the FAIR (Findable, Accessible, Interoperable and Reusable) data standardization. In this way, the new 3D models will be easily integrated and available from the databases. This strategy includes collaboration with the Bureau de Recherches Géologiques et Minières of France (BRGM) and Laboratório Nacional de Energia e Geologia of Portugal (LNEG) in order to harmonize the Spanish geological data and models with their neighbours across national borders. The first step is being done in the framework of GeoERA projects. Financial support for the registration to present this poster comes from Project PID2020-114273GB-C22 funded by MCIN/AEI/10.13039/501100011033.



Towards 3D databases and harmonized 3D models at CN IGME - CSIC

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Background: IGME's geological and geophysical databases.

Present: IGME's 3D models ranging from local studies (mineral exploration, CO2 storage sites, etc.) to regional geology.

Future: Harmonization of the available data to comply with FAIR data standardization and integration of the 3D models in the available datasets.

First step being done in the framework of GeoERA projects and the Coordination and Support Accion (CSA) group of Geological Mapping and Modelling.

The future: Participation in the CSA Project

Geophysical information system (SIGEOF)



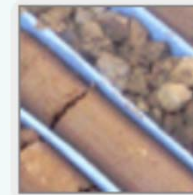
Seismic profiles
(Tiff and seg-y)
Gravity
Aeromag and
radiometric data
VES, electrical
profiles, MT, MRS,
Well logs (LAS)

Water supply points



74600 Water
supply points with
its
Lithological
columns

Well log cores repository Peñarroya (Córdoba)



12400 Well logs
with lithological
information,
reports, cores,
cuttings, etc.

Hidrocarbon database



Reports from
hidrocarbon
exploration
companies
Maps, log, seismic
lines, cross
sections, etc.

Digital geological cartography



Geological maps
Thematic maps
(hidrog.,
geomorph.,
geotec.,
methalogen.)

Reports' information system(SIS)



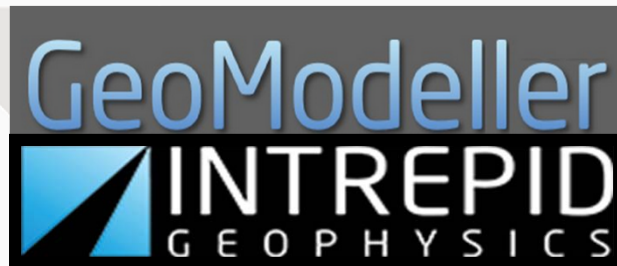
Reports from
geophysical surveys
and drilling.

<http://info.igme.es/catalogo/default.aspx>

Present: Software we use for 3D modelling



GMSYS for 2.5D potential field modelling prior to digitize in GeoModeller.
GMSYS3D, potential field modelling, models build up from surfaces (simple models).



3D potential field modelling. Initial model based on geological data (surface geology, cross sections, drillholes).



3D geological modelling:
petrophysical data, facies,
etc.



2D y 3D geological
modelling and restitution

TOUGH2

Numerical simulation multidimensional fluid flow in porous and fractured media

MODFLOW

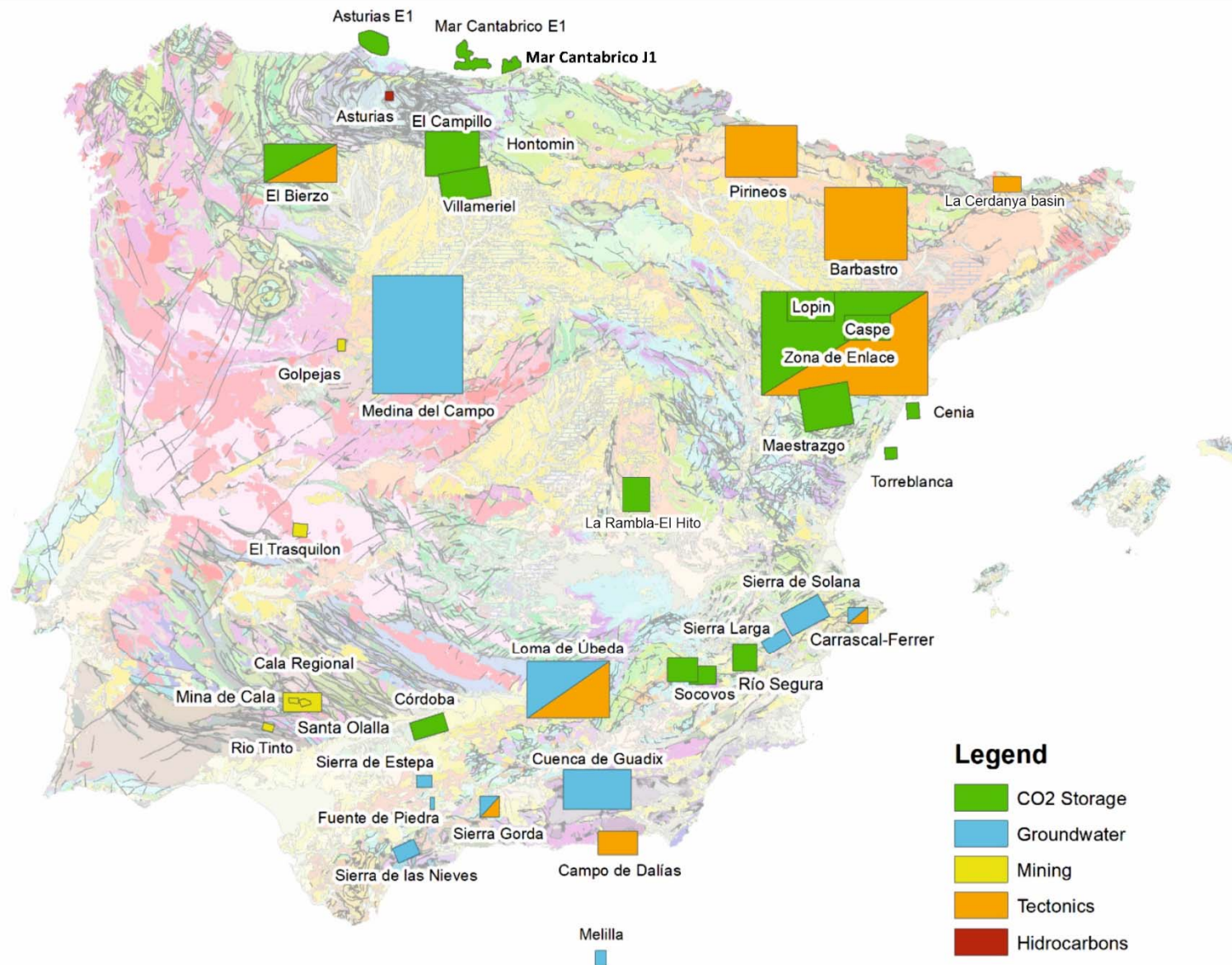


Numerical simulation of groundwater flow through aquifers

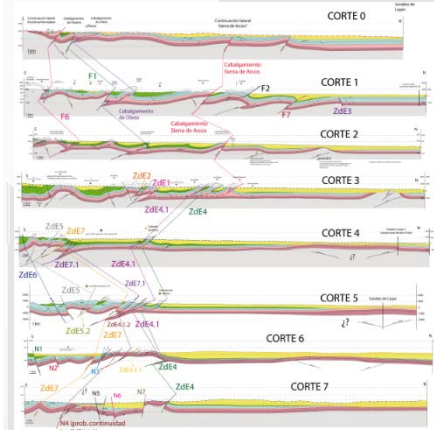
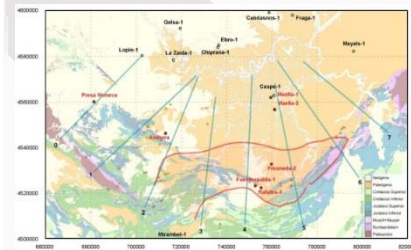
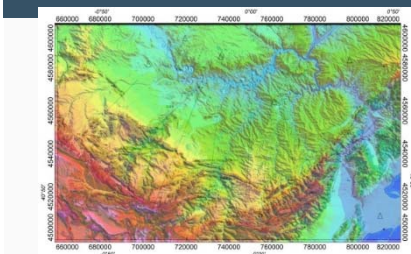
TRANSDENS



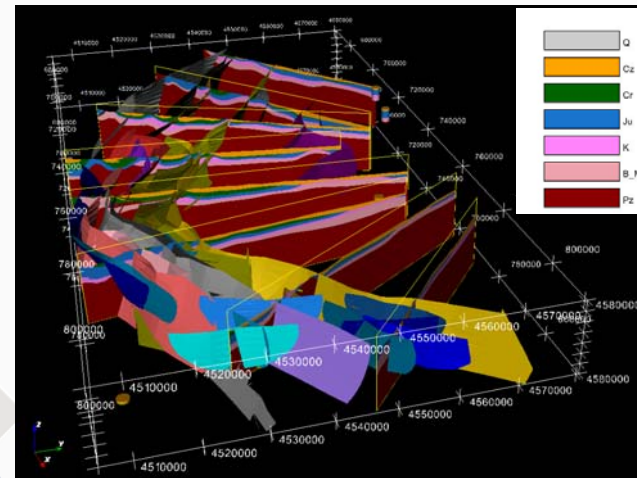
Simulation program that solves the equations of flow and transport in porous media



Present: Example of optimized workflow for building 3D models (Linking Zone)

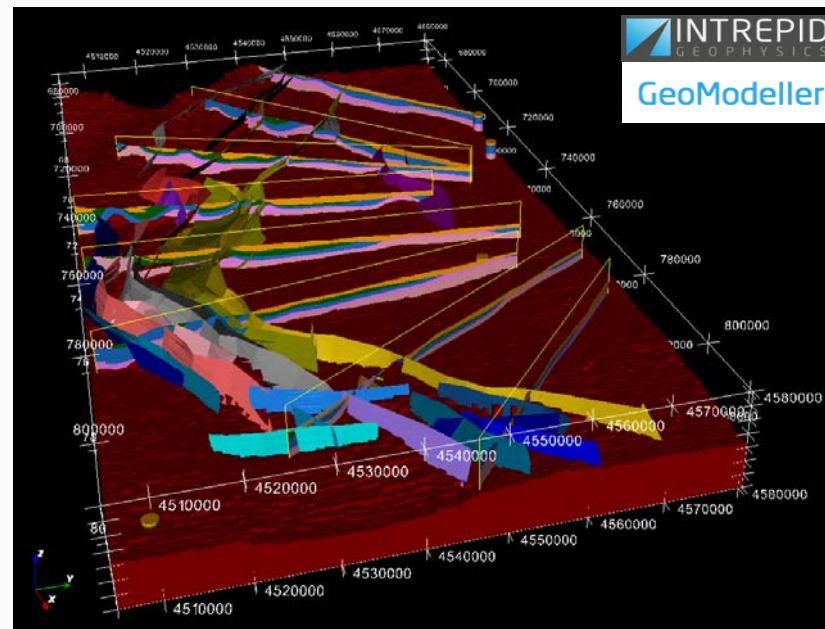


Topography, geology, petrophysical data, balanced cross sections, gravity data (we include seismic and other geophysical data when available)



Initial 3D geological model

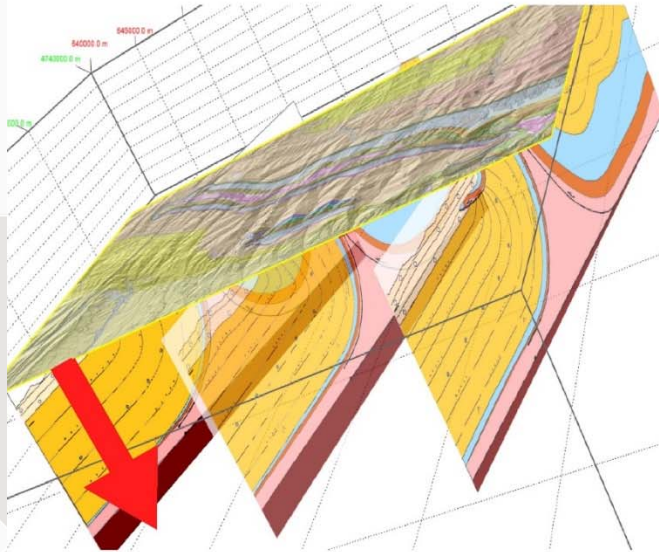
Formation Density (g/cm³)	
Q	Normal(1.8,0.05,100)
Cz	Normal(2.4,0.05,100)
Cr	Normal(2.56,0.05,100)
Ju	Normal(2.62,0.05,100)
K	Normal(2.25,0.05,100)
B_M	Normal(2.57,0.05,100)
Pz	Normal(2.68,0.05,100)
General Parameters	
Density	
Reference Density (g/cm³)	2.67



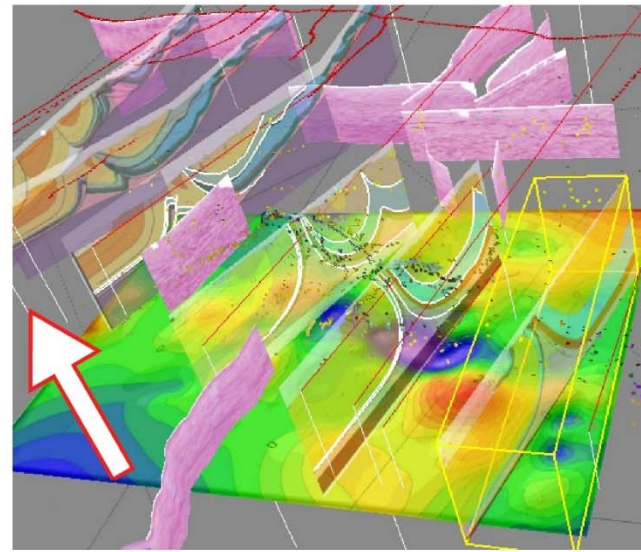
The model is improved through stochastic gravity inversion

Present: Example of optimized workflow for building 3D models (Pyrenees)

Serial Balanced Sections Top to Down



Gravimetry Bottom up



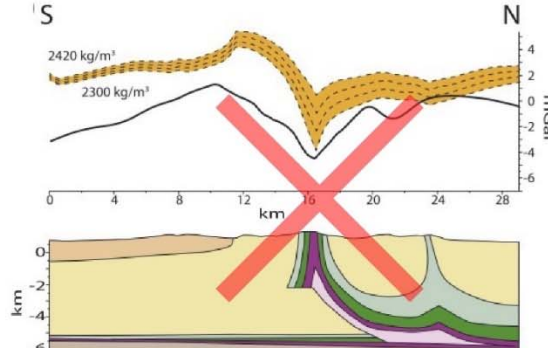
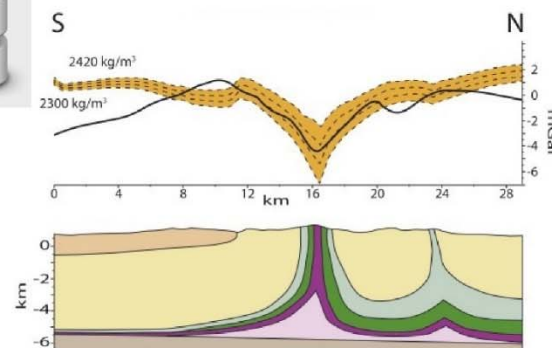
Petrophysics



Integration Triple balancing of geometry, petrophysics and gravity signal

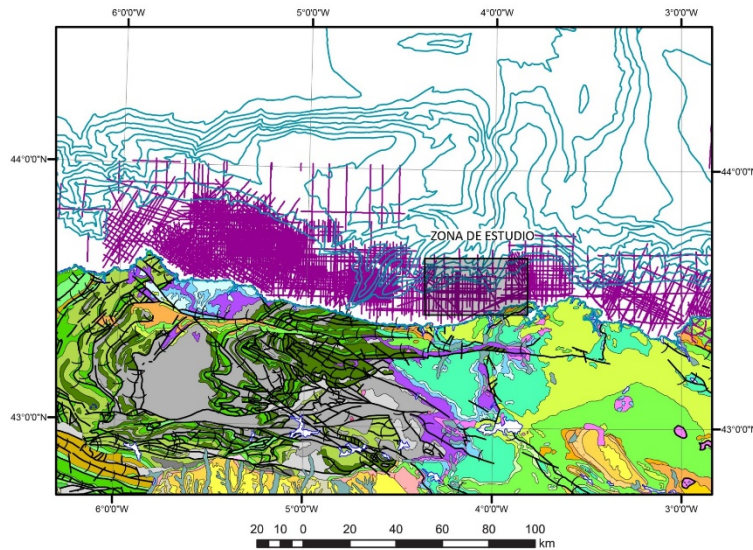
FEED
BACK

2D 3D

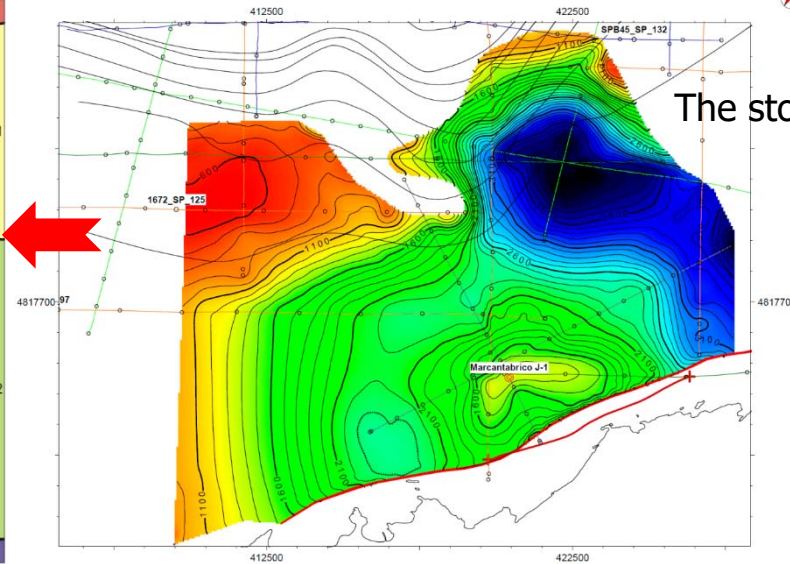
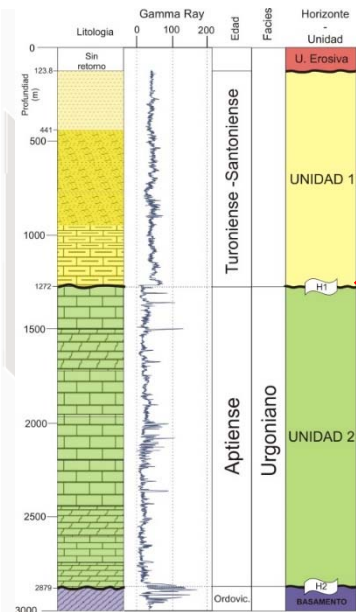
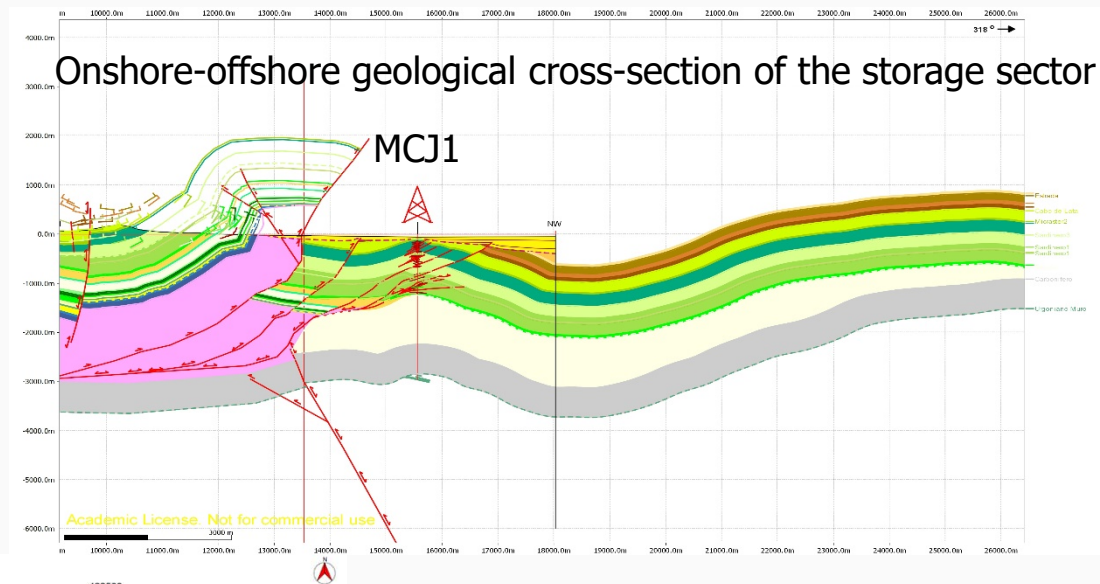


Present: Example 3D models offshore, CO₂ storage

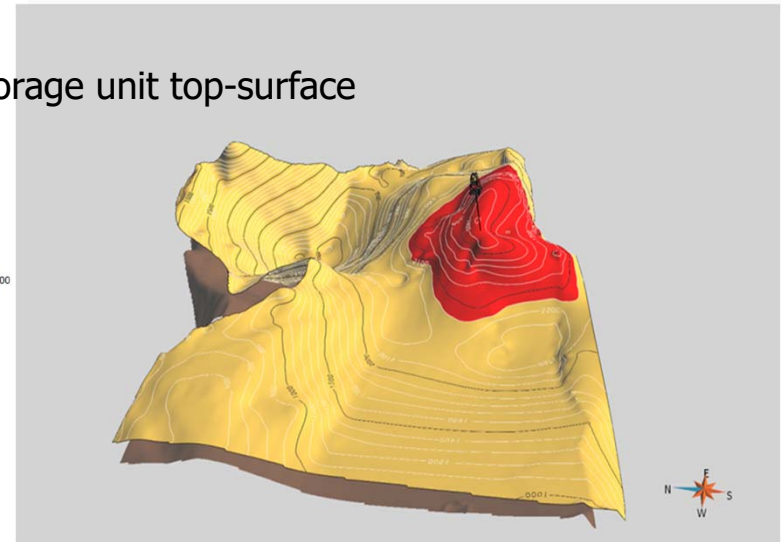
Multichannel seismic lines around Mar Cantabrico J-1 (MCJ1) well



Onshore-offshore geological cross-section of the storage sector

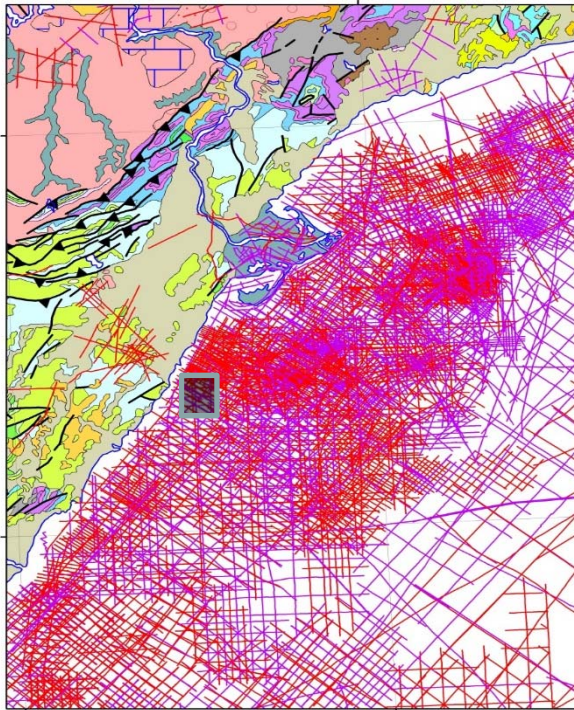


The storage unit top-surface

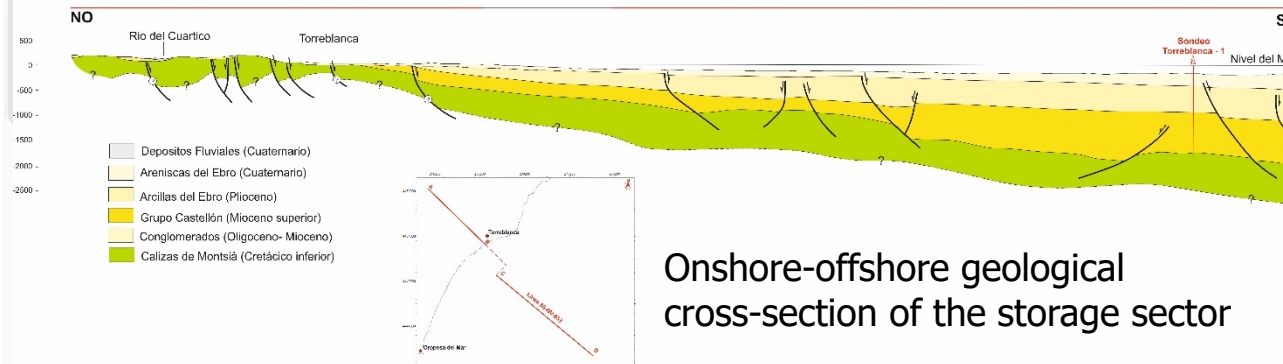
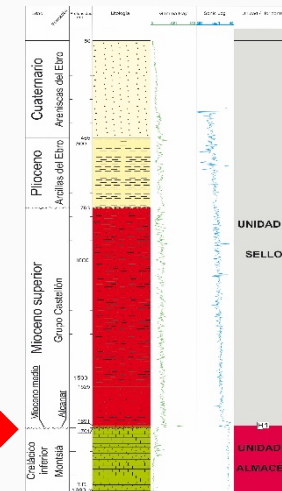
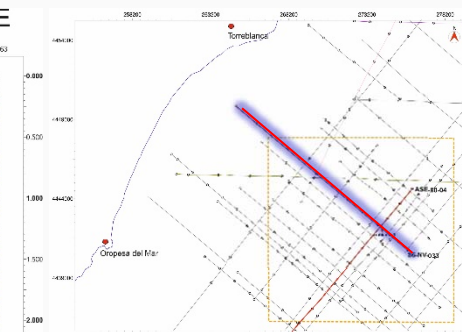
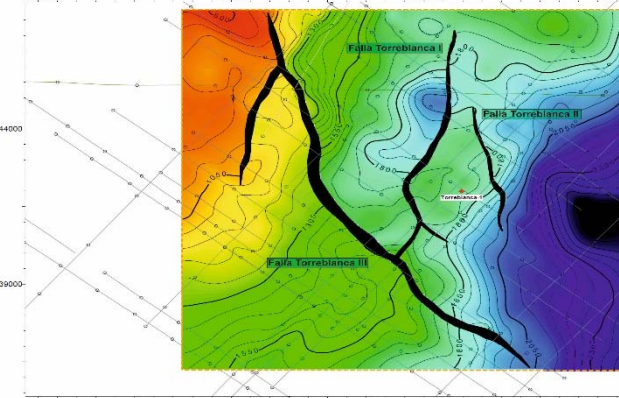
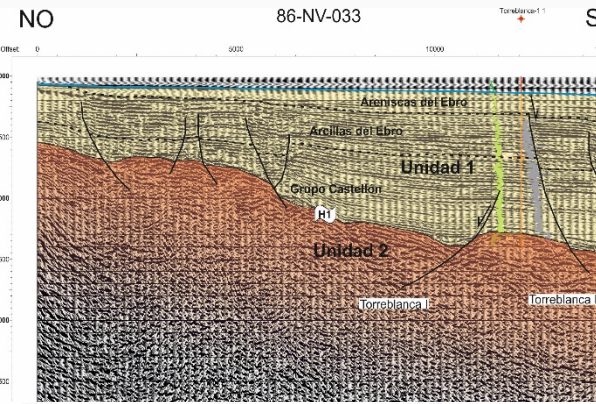


Present: Example 3D models offshore, CO₂ storage

Multichannel seismic lines around Torreblanca-1 well

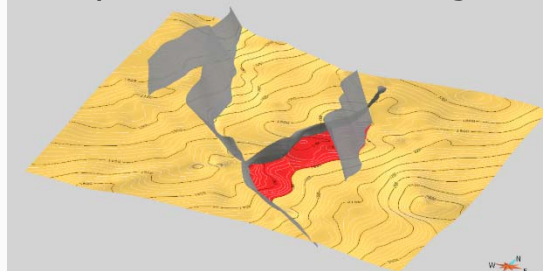


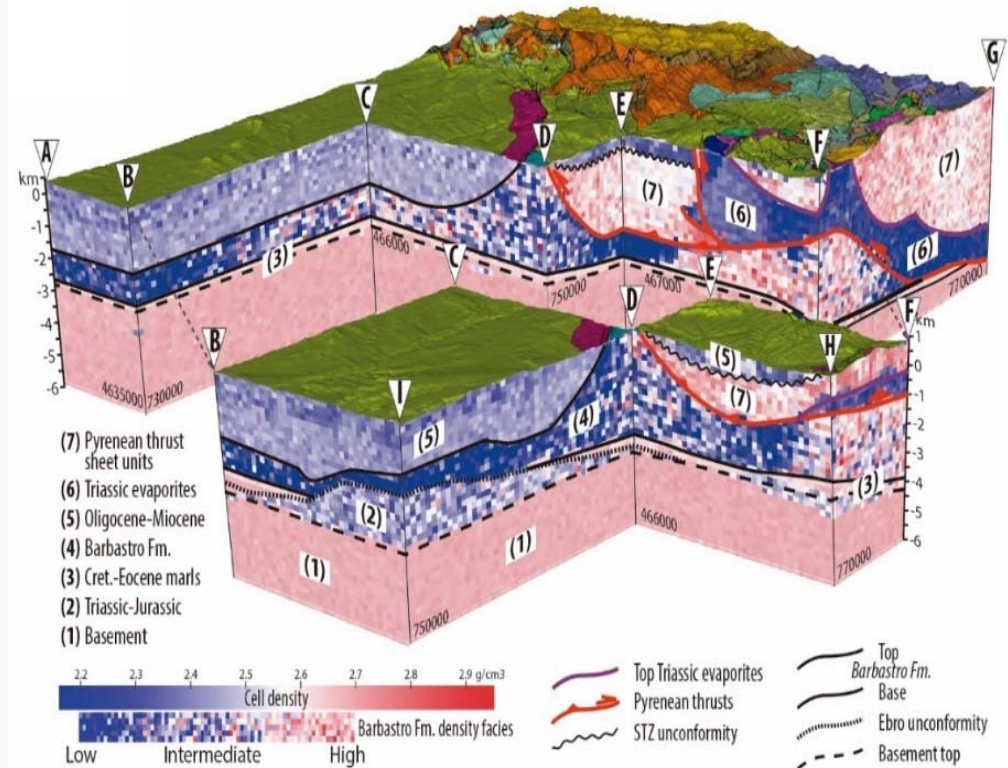
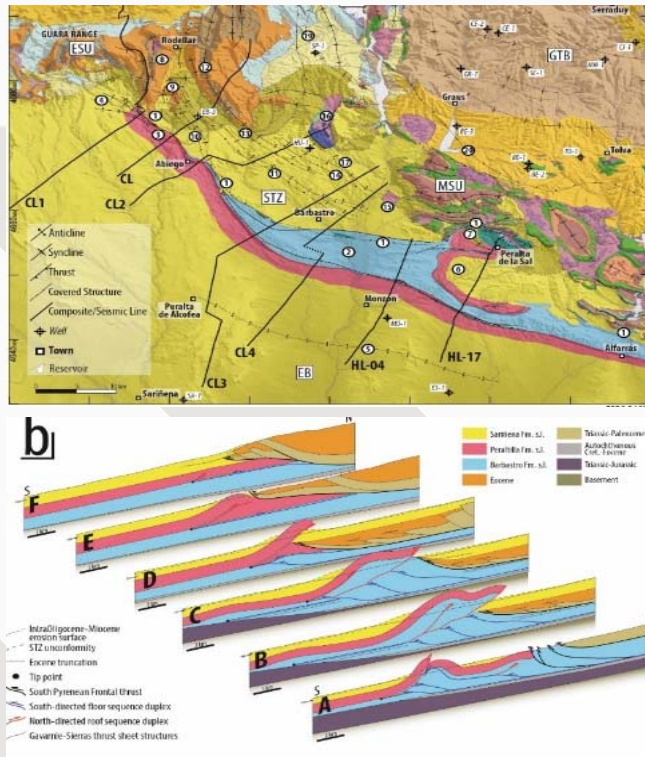
A MAGNA Hoja 594(Alcala de Chivert) B C



Onshore-offshore geological
cross-section of the storage sector

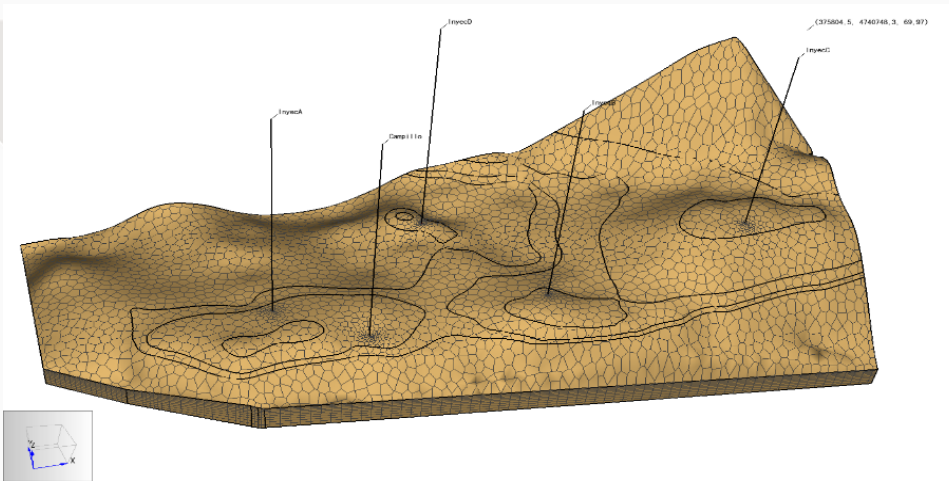
Top-surface of the storage unit



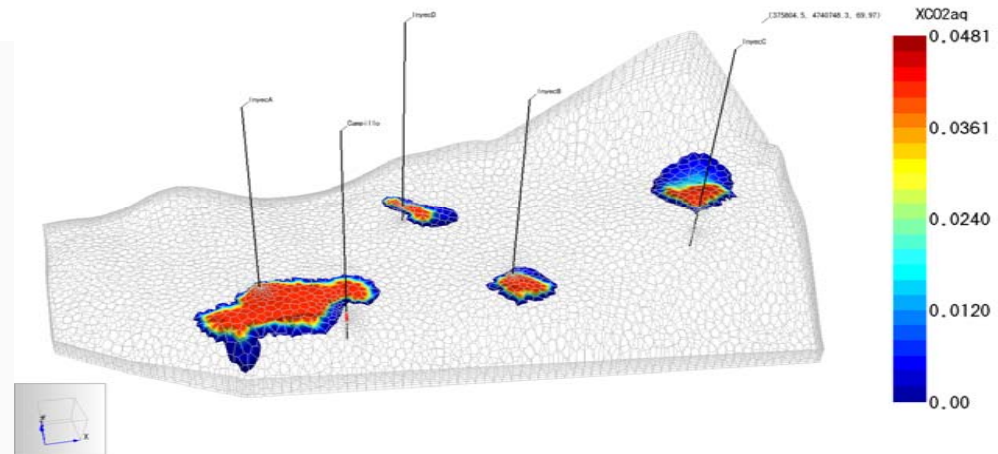


**Barbastro Anticline (Pyrenees): Gravity inversion (density distribution).
Integration of structural, geophysical (seismic sections and gravity
anomalies) and petrophysical data**

El Campillo: Dynamic simulation of the CO₂ injection

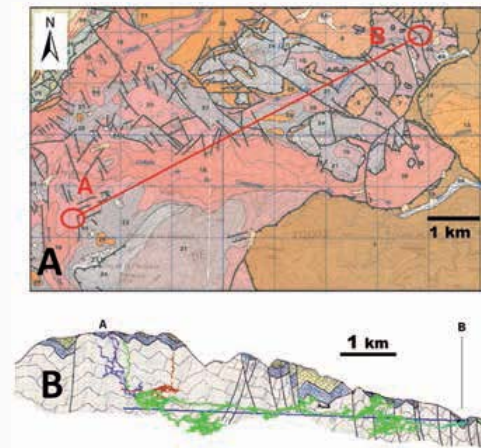
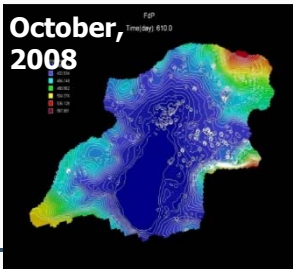
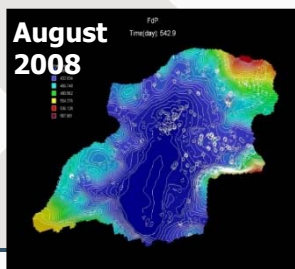
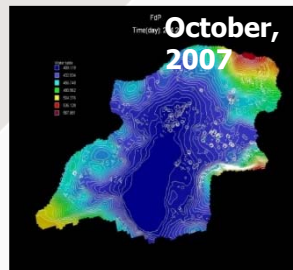
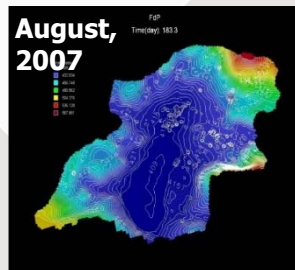
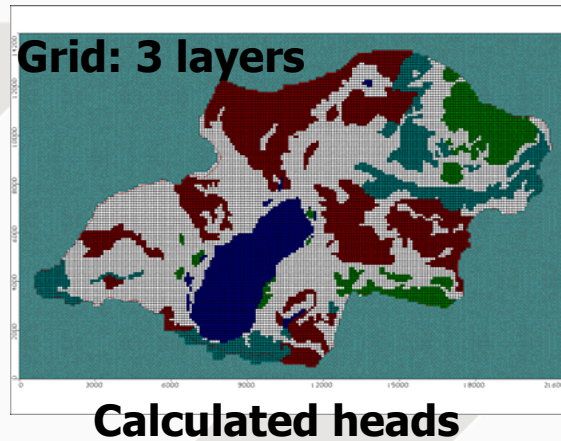


Geological model

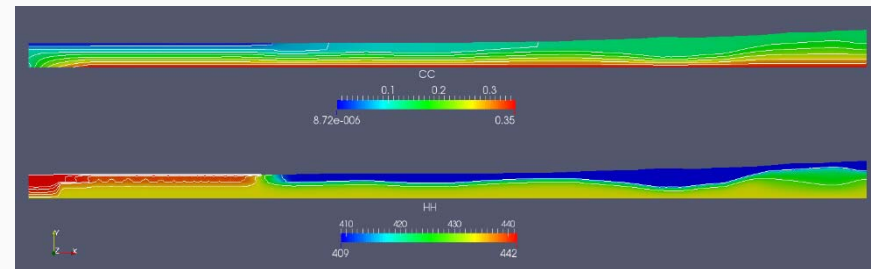


Evolution of the CO₂ plume with time

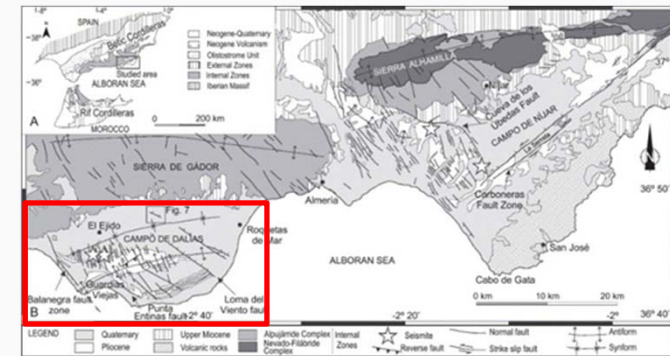
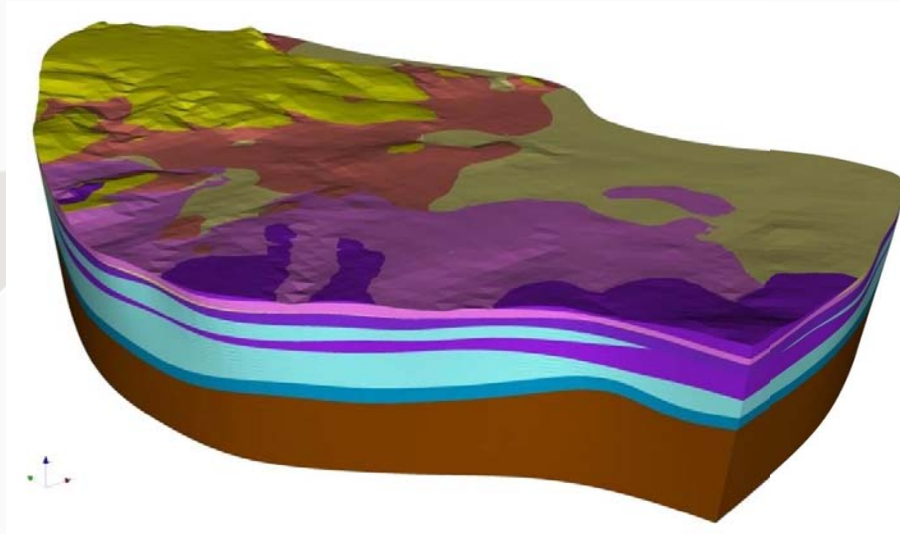
3D Constant head flow model
(density-dependent flow) [MODFLOW]
A hypersaline hydrogeological system:
Fuente de Piedra Lake



3D stochastic simulation of karst conduits networks
(Sierra de las Nieves, Málaga)



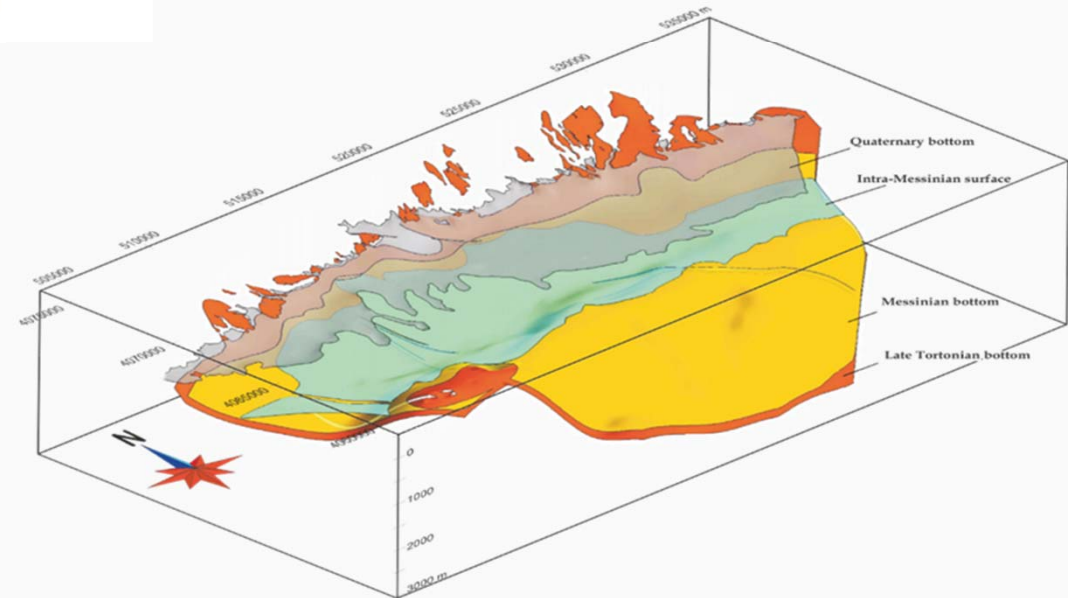
3D density-dependent groundwater flow (and
transport) model (TRANSDENS). Calculated
concentrations and heads. $t = 41$ years (Fuente de
Piedra Lake)

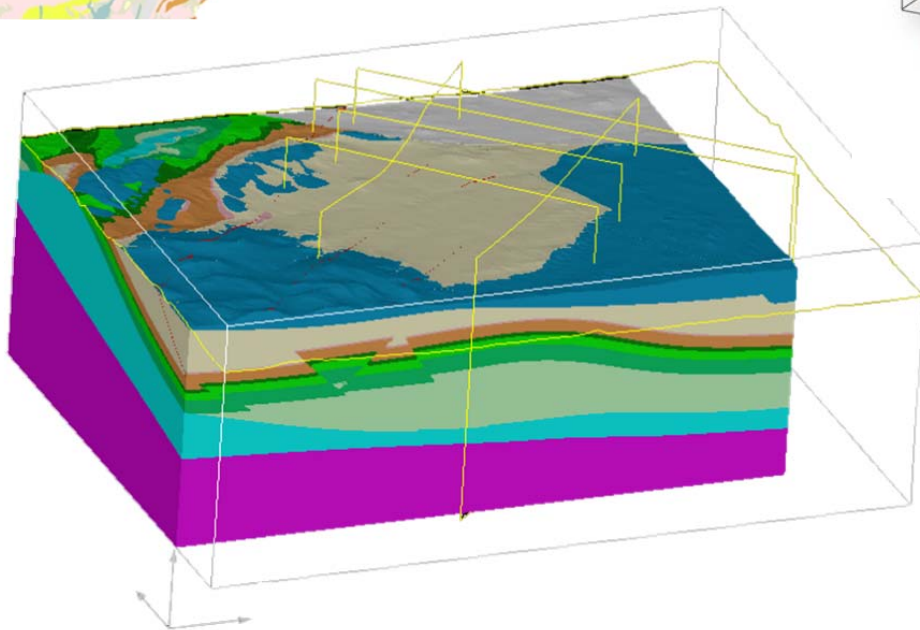
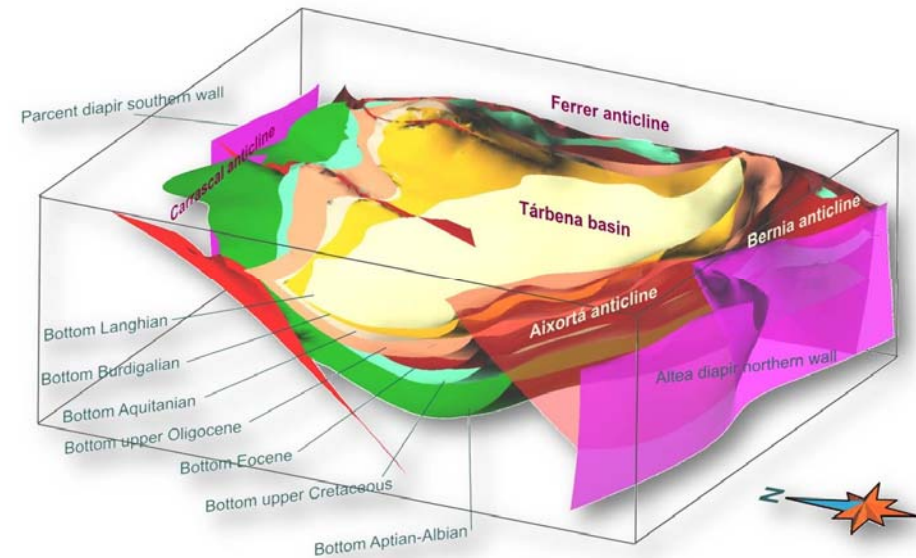
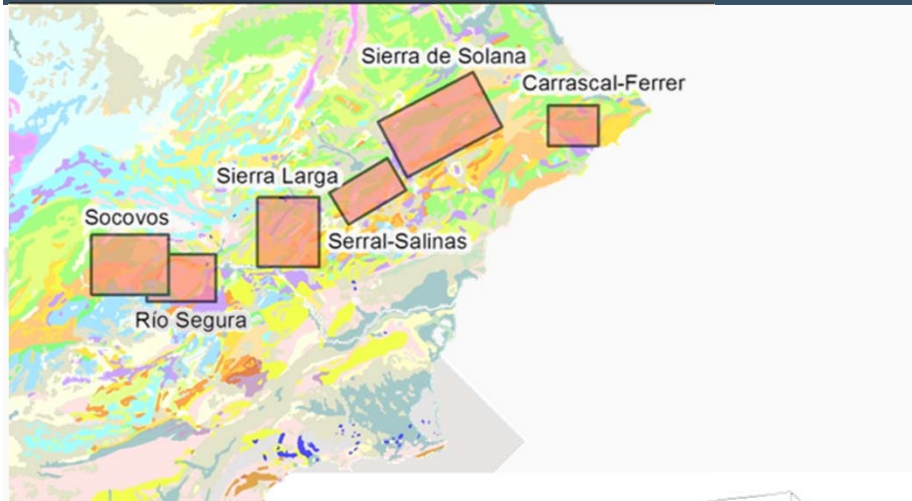


Campo de Dalías (tectonic model)



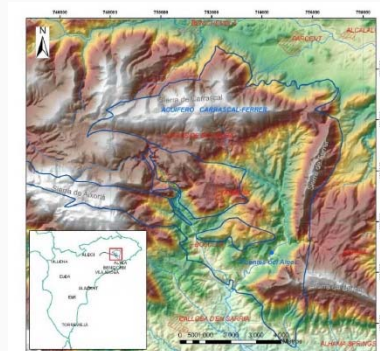
Melilla model
(hidrogeology)





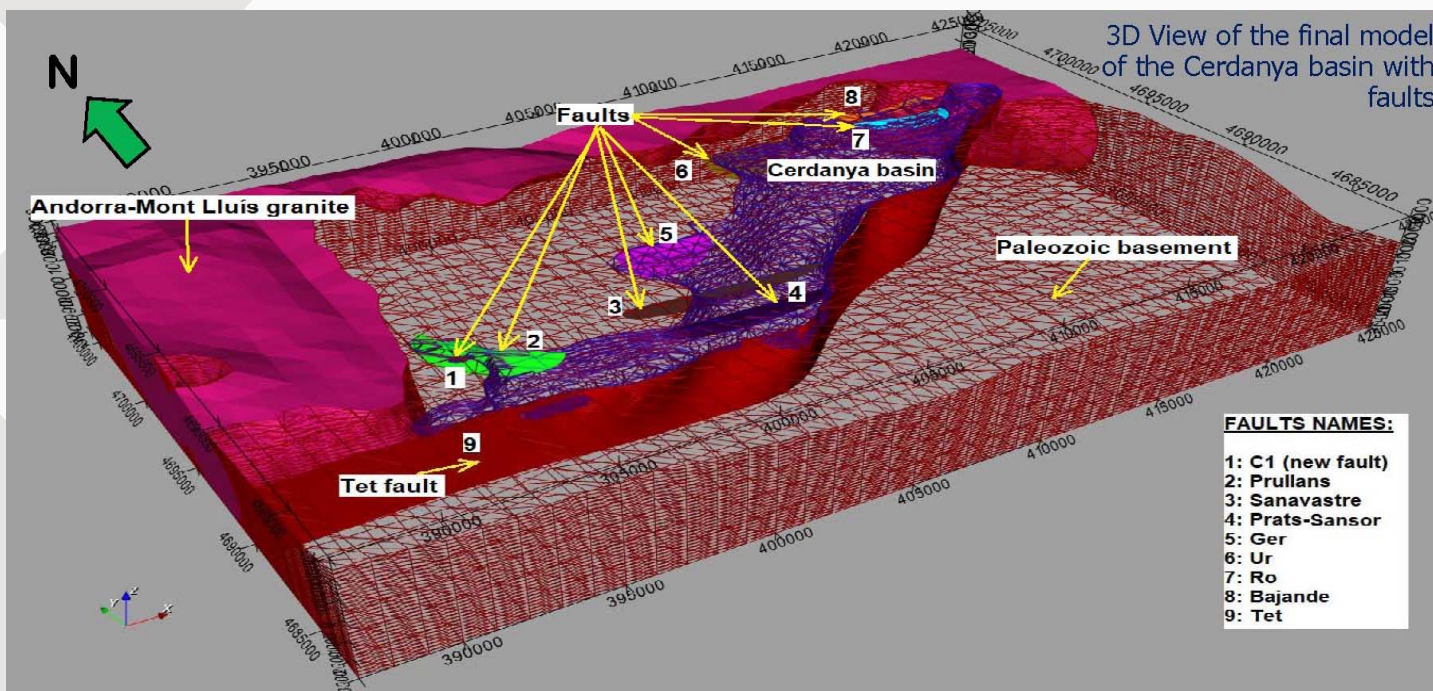
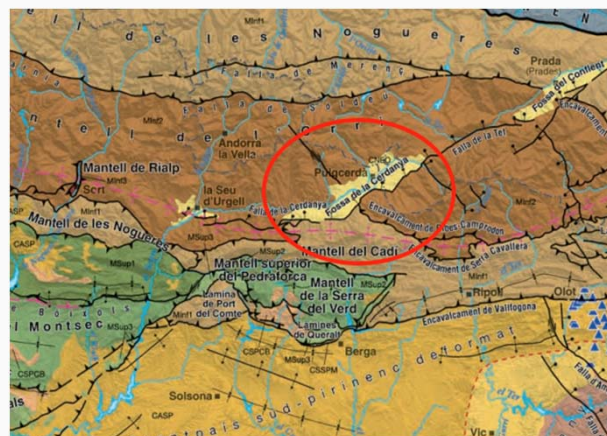
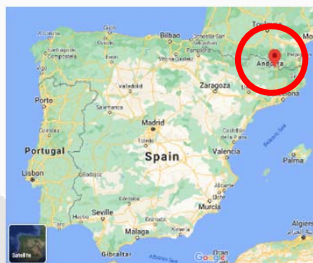
Río Segura model (CO2 storage)

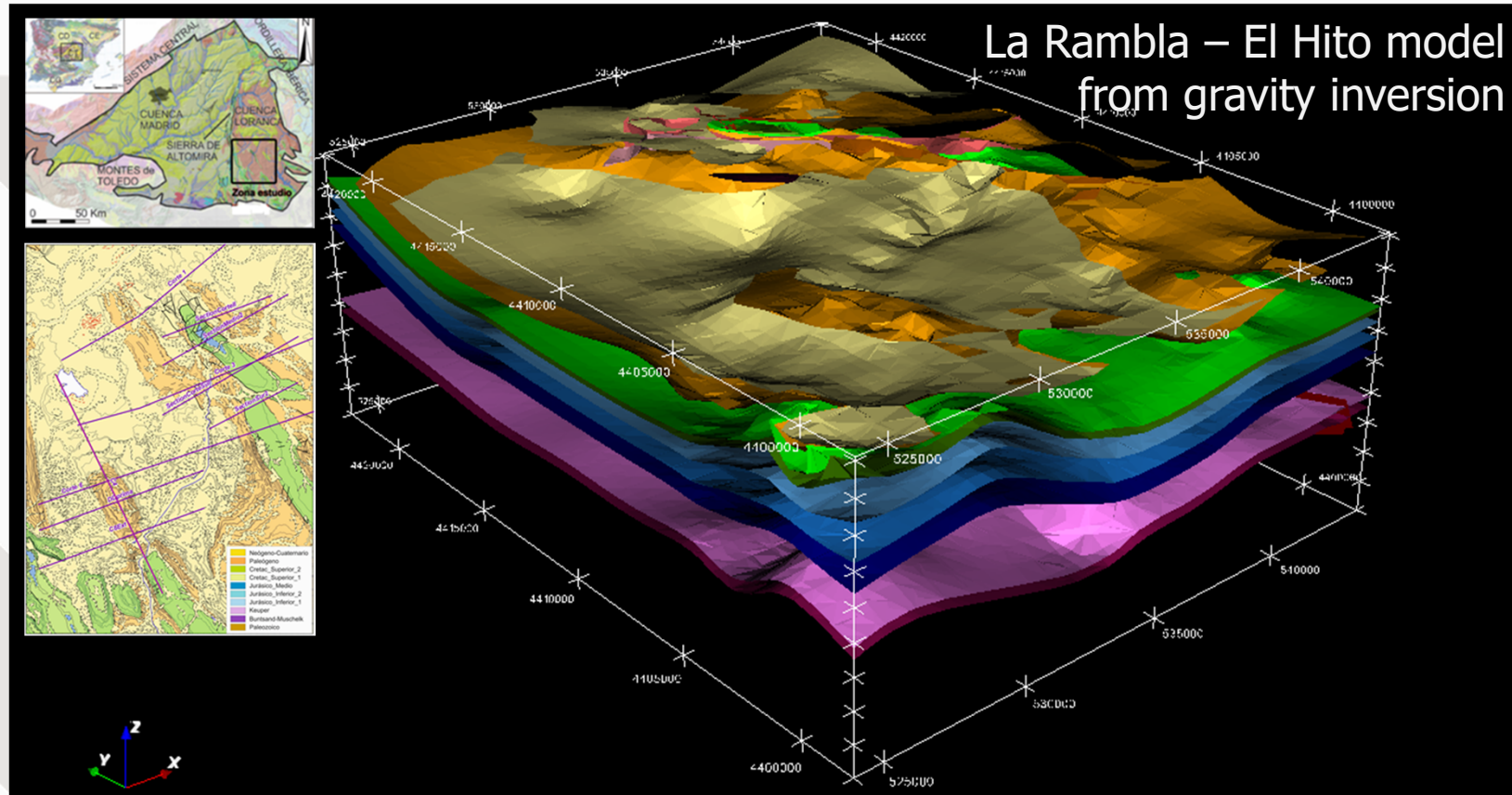
Carrascal Ferrer
model
(hidrogeology)





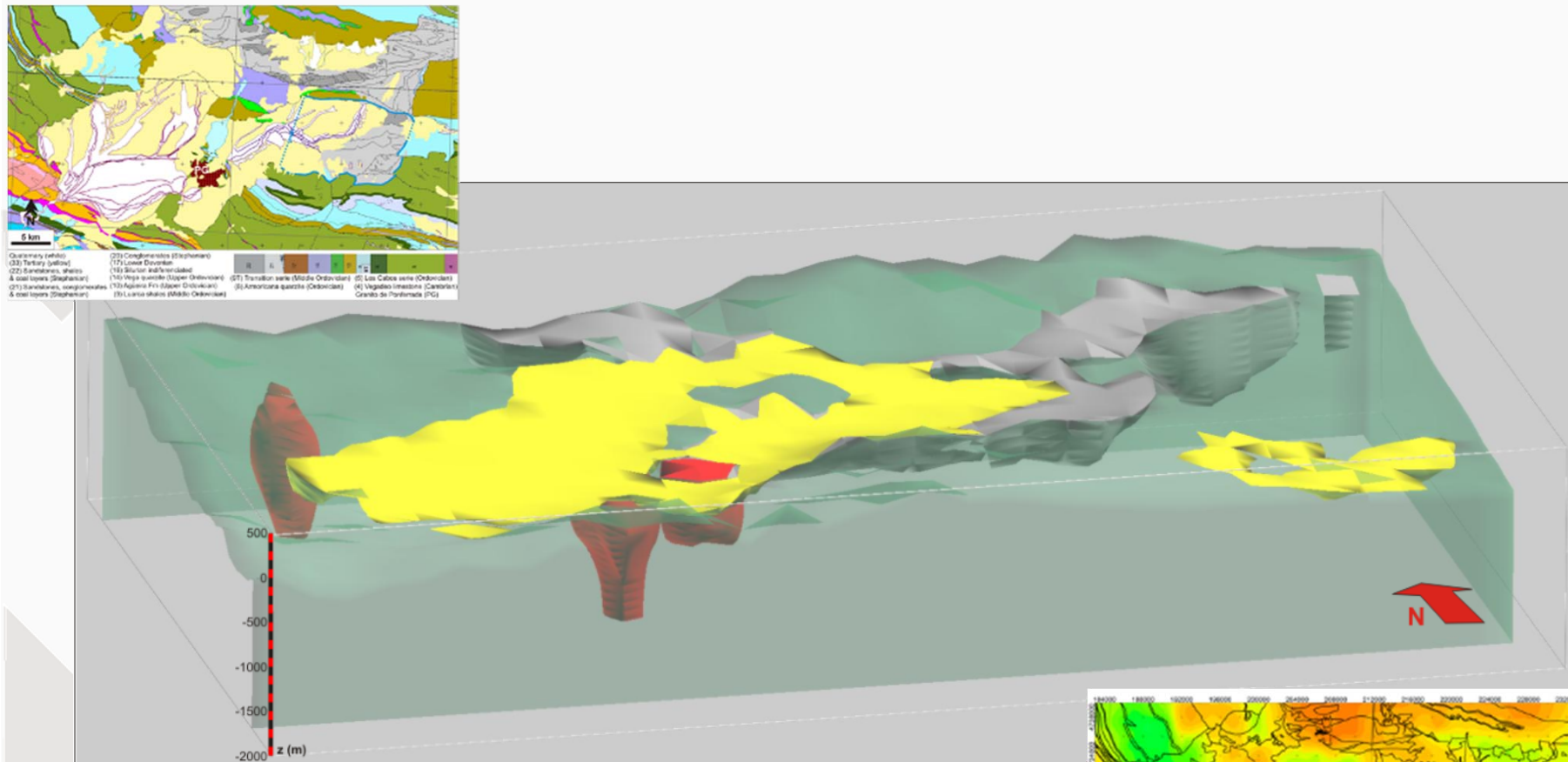
Present: Example 3D models onshore, tectonics, La Cerdanya basin



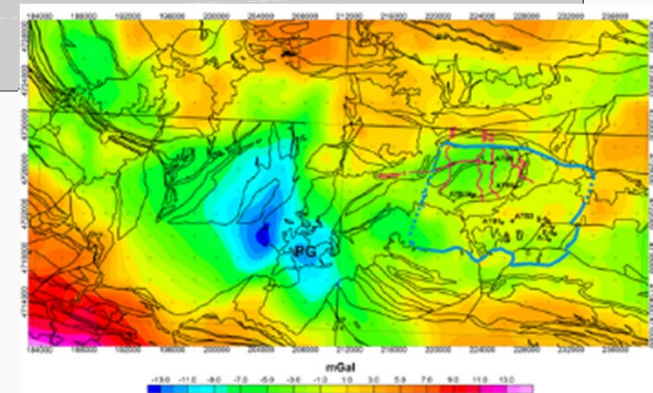




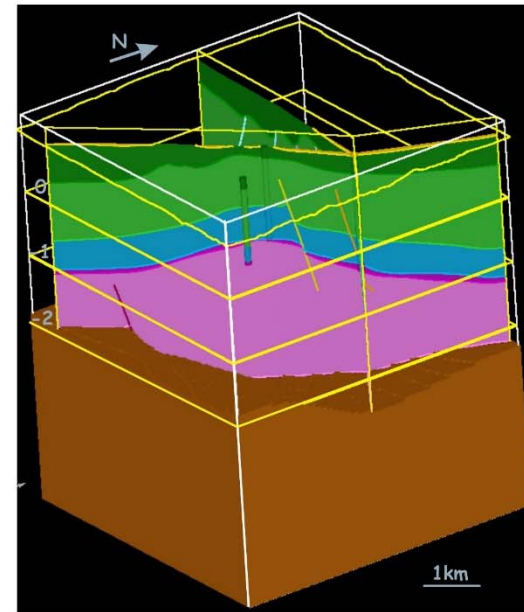
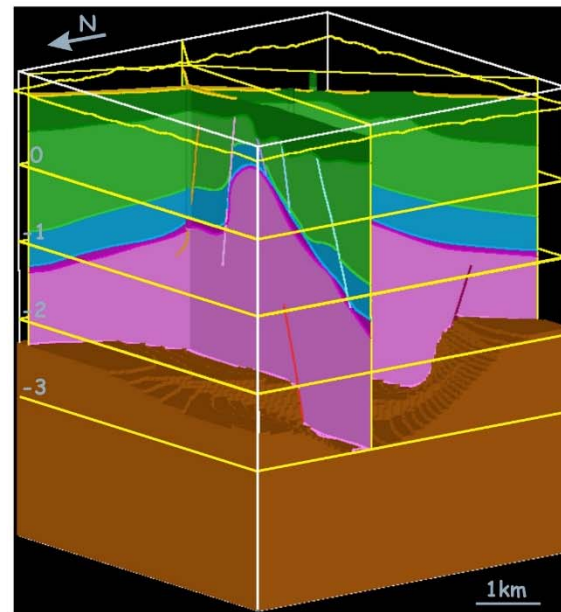
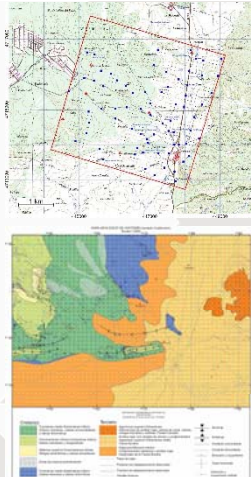
Present: Example 3D models, El Bierzo (tectonics and CO₂ storage)

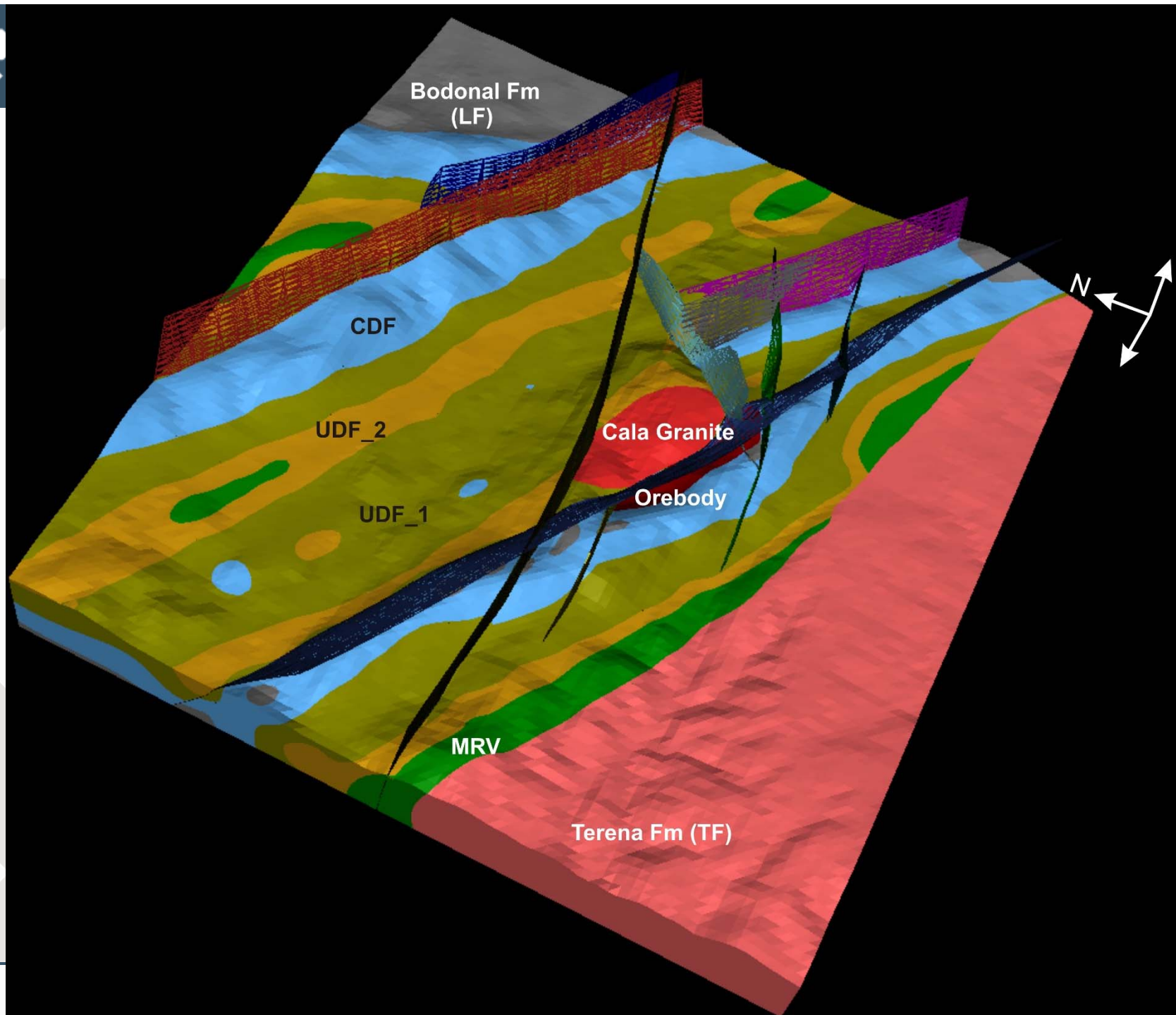


El Bierzo: Geological map, residual Bouguer anomaly and 3D geological model from gravity inversion



3D Model Hontomín
geological structure from
gravity inversion





Findability – IGME databases make easy to find the data that you are looking for, we are in the process of designing the structure for a 3D models storage. All data has its associated metadata (Inspire).

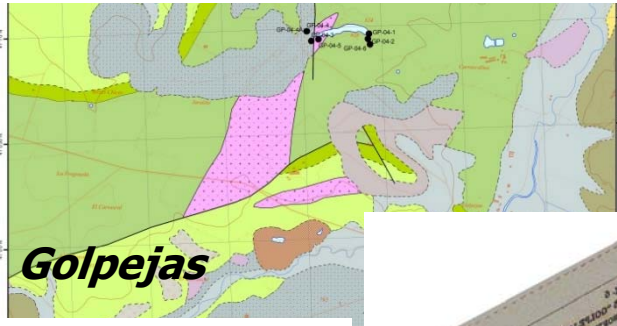
Accessibility – IGME databases are accessible from the Web (and free of charge).

Interoperability – We are working towards the interoperability of the data regarding 3D models. The main issue being finding appropriated formats to deliver the data.

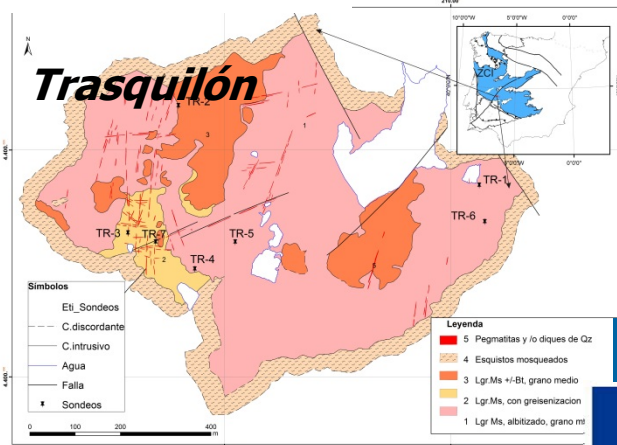
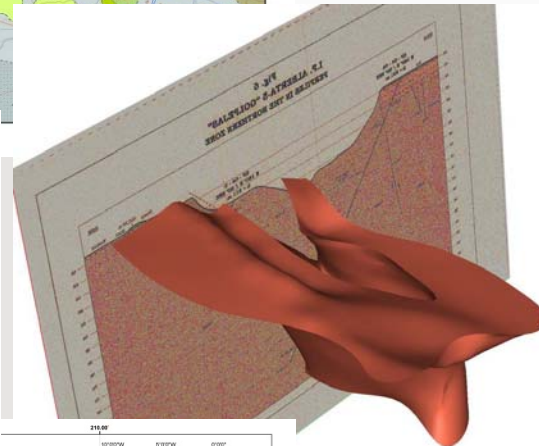
Reusability – Once solved the issue of the formats, data accessibility with their corresponding metadata will make the 3D models or part of these models reusable.

First step: Example GeoERA projects (1/2)

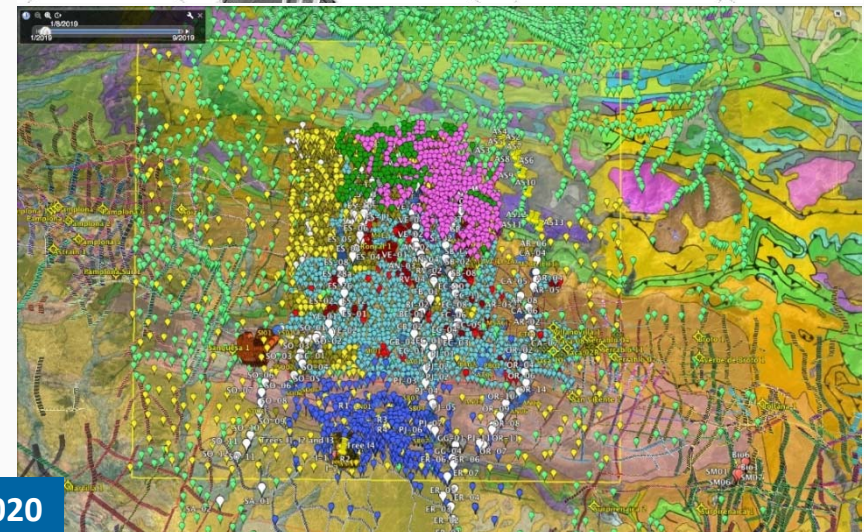
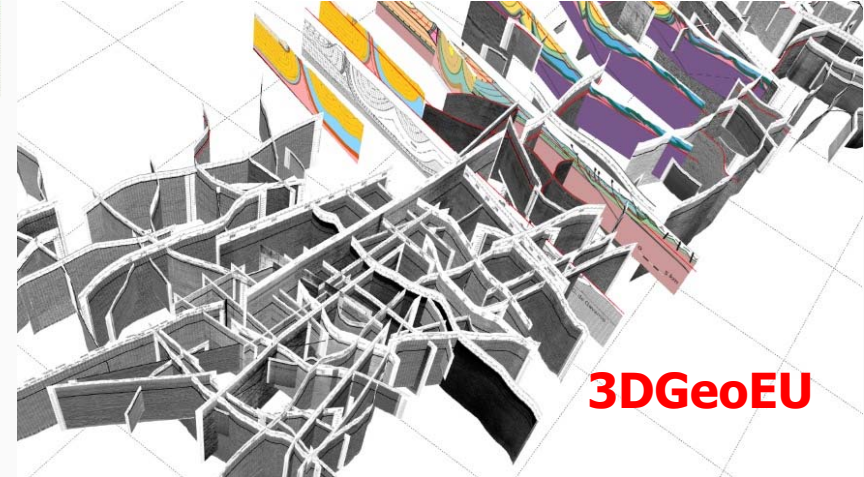
Integration of geological, borehole,
geochemical and petrophysical data



Forecasting and
Assessing
Europe's
Strategic Raw
Materials needs
(FRAME)



Integration of geological, seismic, gravimetric
and petrophysical data across borders



ERA-NET Cofund under 2020



Horizon 2020

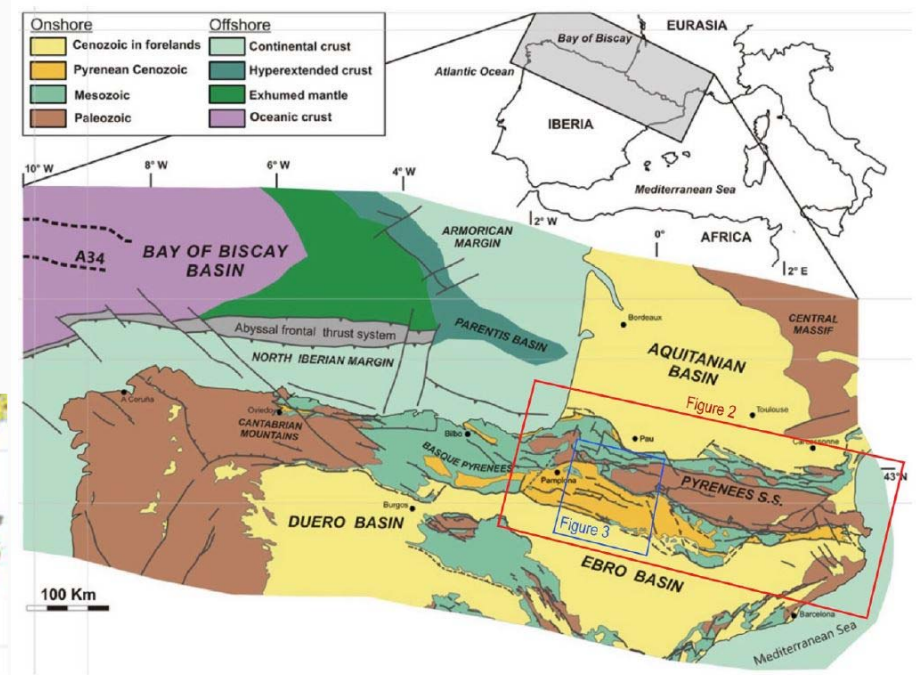
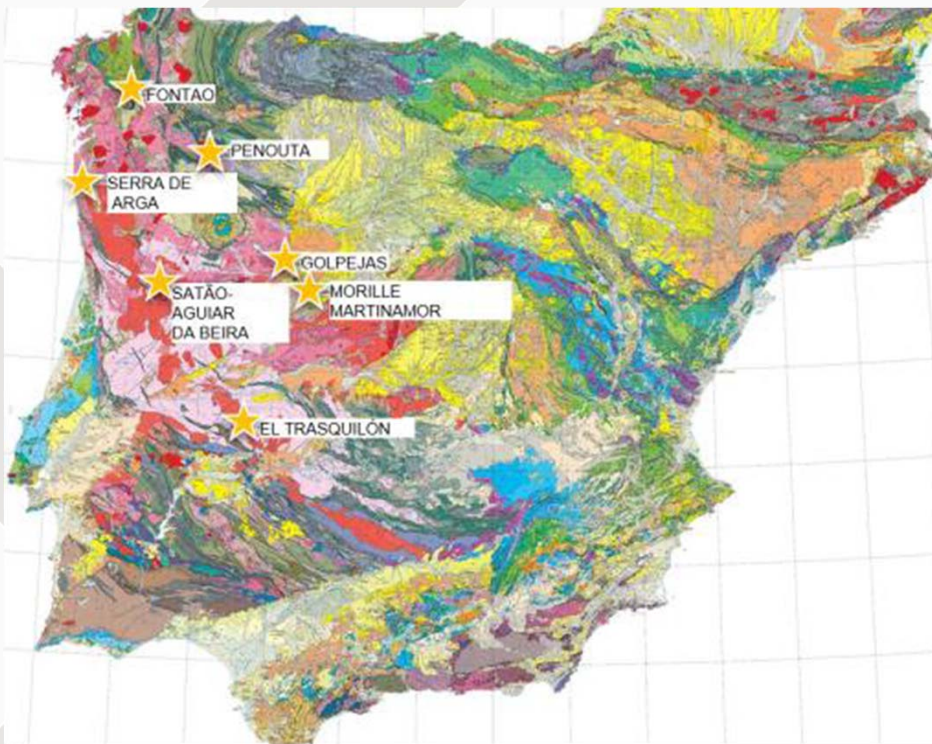
Western Pyrenees, 2018-2021

Cofund action 731166 [H2020],

Project code **GeoE.171.005**

Location maps GeoEra models

Granites studies within FRAME



Blue rectangle: Study area 3DGeoEU

The future of FAIR 3D modelling at IGME will be strengthened in the European Geological Survey by the participation in the CSA (Coordination and Support Accion) Project within the framework of Horizon Europe.

This future Project involves all the EGS with the aim of establish a Geological Service for Europe.

One of the tasks we are involved is 3D Geomodelling and Mapping within the WP6, Geological framework for the digital European geological information system.

Thank you for your attention

