Basement characterization and cover deformation of the Linking Zone (NE Spain) from 2.5D and 3D geological and geophysical modelling.

Concepción Ayala (1,2), Esther Izquierdo-Llavall (3), Félix Rubio (1), Emilio Pueyo (4), Antonio Casas (3), Belén Oliva-Urcia (5), Adriana Rodríguez-Pintó (3), Carmen Rey-Moral (1) and José F. Mediato (1)

(1) Instituto Geológico y Minero de España (IGME). Tres Cantos - 28760 Madrid. c.ayala@igme.es, fm.rubio@igme.es, c.rey@igme.es, jf.mediato@igme.es.

(2) Now visiting at ICTJA-CSIC, C/ Lluis Solé Sabaris s/n, 08028 Barcelona, Spain.

(3) University of Zaragoza, Ciencias de la Tierra, Zaragoza, Spain; estheriz@unizar.es, acasas@unizar.es, adrianar@unizar.es

(4) Instituto Geológico y Minero de España (IGME)-Unidad de Zaragoza, Manuel Lasala 44, 50006 Zaragoza, Spain; unaim@igme.es

(5) Dpto. de Geología y Geoquímica. Universidad Autónoma de Madrid. Ciudad Univ. de Cantoblanco , 28049 Madrid; belen.oliva@uam.es

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

ICTJA CSIC

Aim:

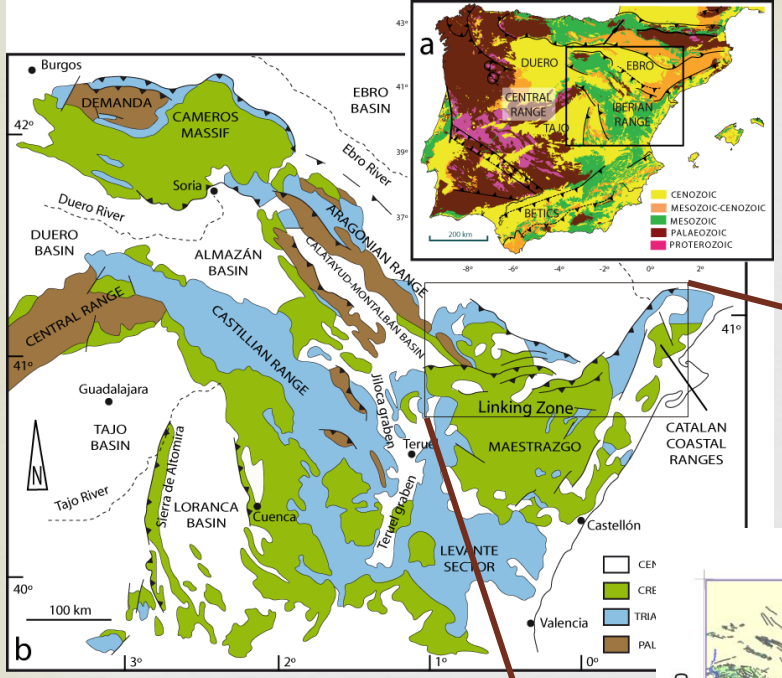
To improve the understanding of the upper crustal structure in the Linking Zone through 3D geological and geophysical modelling

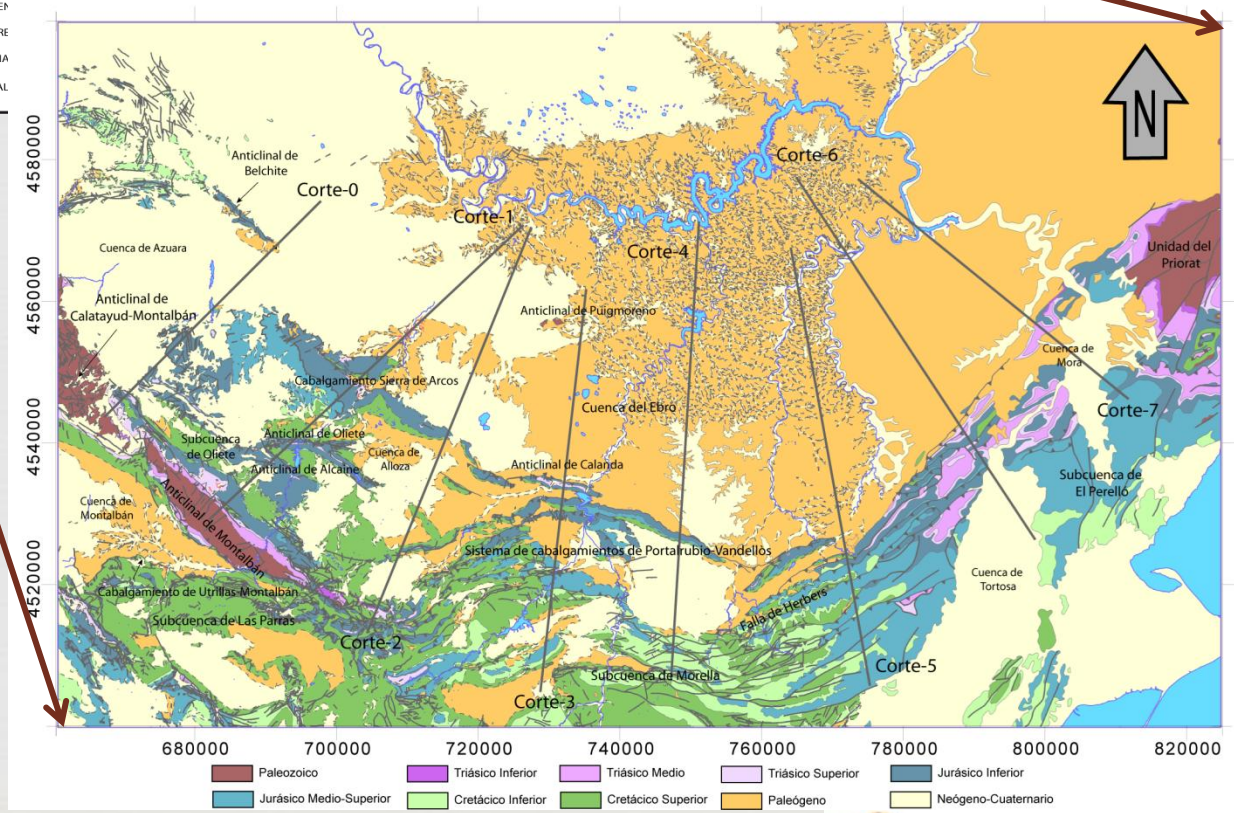
Outline:

- Geological setting
- Surveys
- Petrophysical data
- Geophysical data
- 2.5D modelling; Results
- 3D modelling; Results
- Conclusions

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Instituto Geológico y Minero de España
ICTJA CSIC

Geological Setting





Study area and location of the cross-sections (Corte 0 to 7). The main toponims are also indicated.

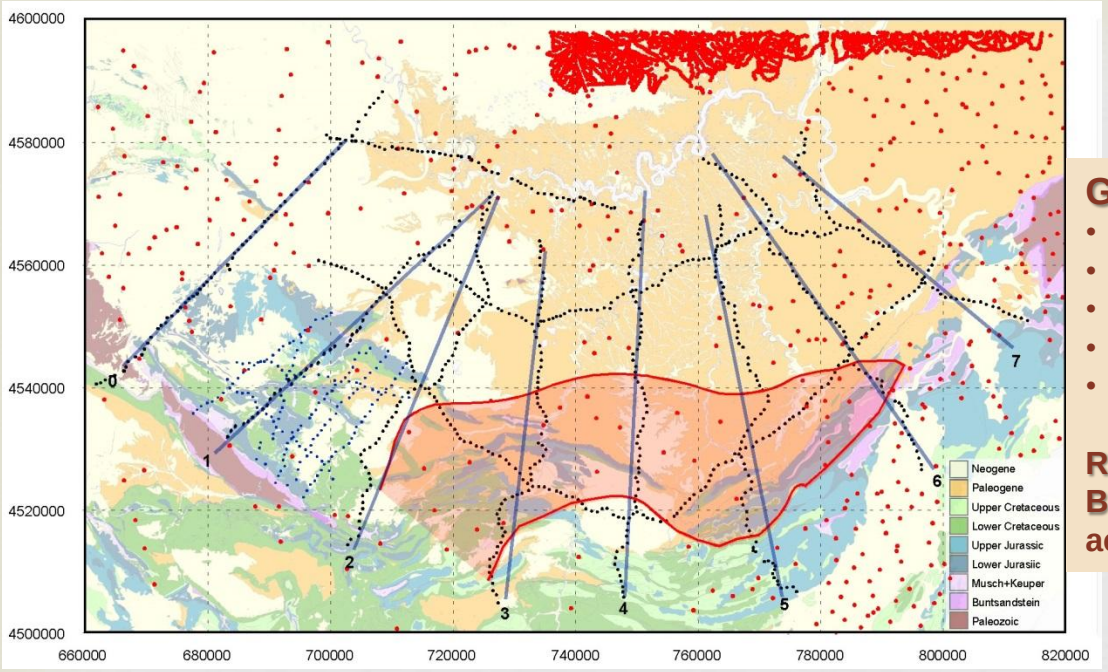
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

ICTJA

CSIC

Surveys

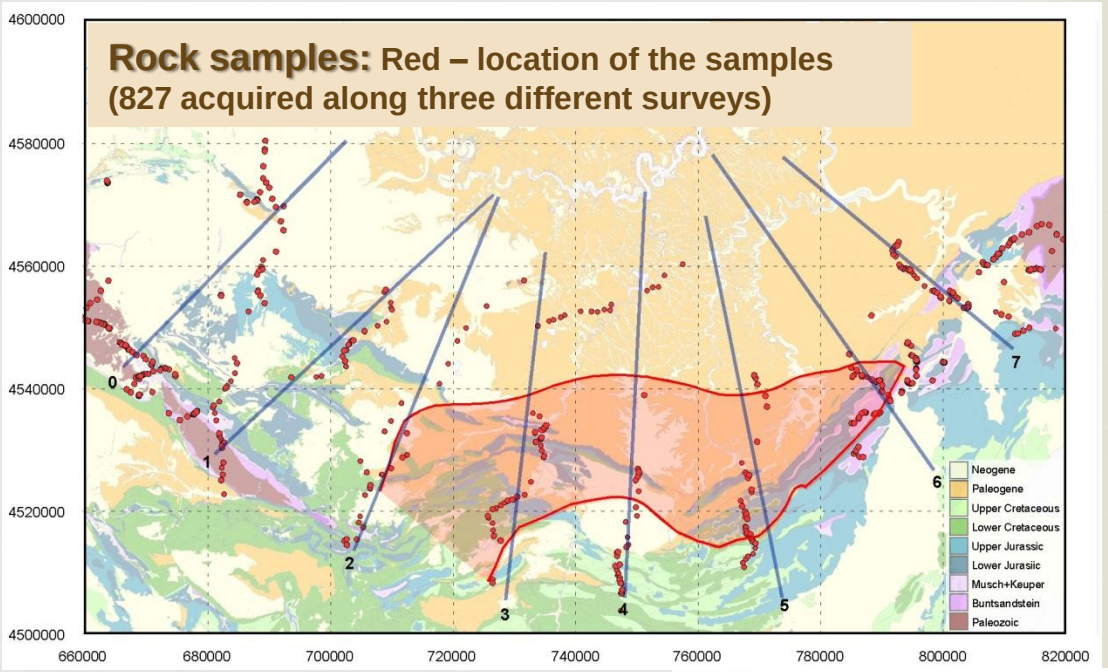


Gravimetric Surveys, 1:50000 scale

- RMS X coordinate: 0.22 m
- RMS Y coordinate: 0.15 m
- RMS Z: 0.11 m
- RMS gravity measurements: 0.02 mGal
- Uncertainty Bouguer anomaly: 0.04 mGal

Red – 1953 stations from IGME database
Black and blue – 938 new stations specifically acquired for this work

Shaded in red, the location of the initially assumed area as possible CO_2 storage site



MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Instituto Geológico y Minero de España
ICTJA
CSIC

Petrophysics

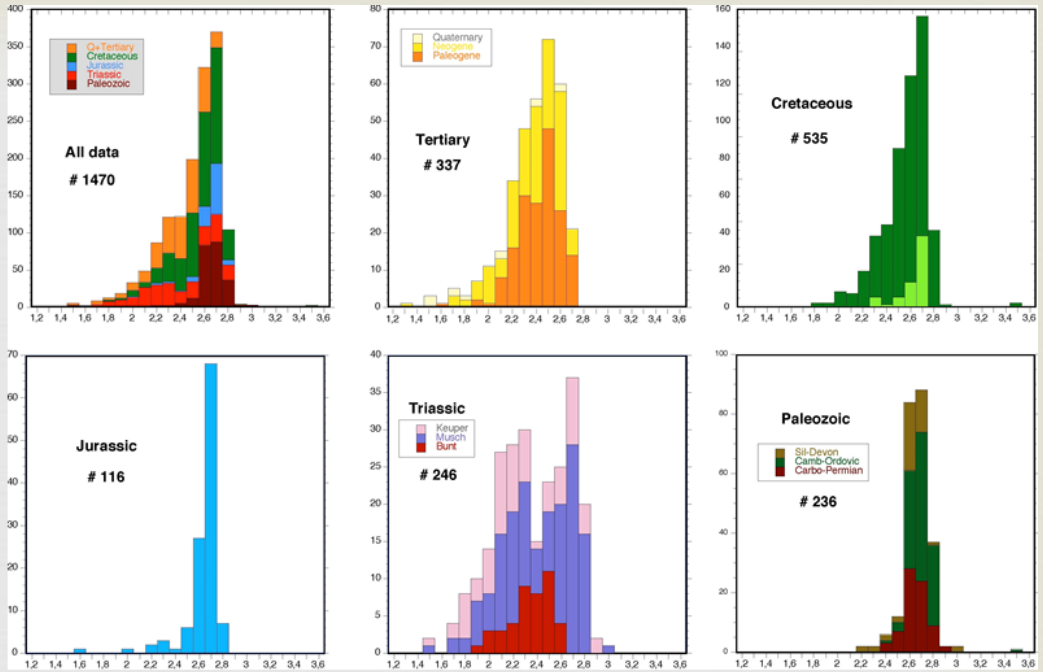
1470 samples:

- 827 from this project
- 643 from public databases

Densities (g/cm3)

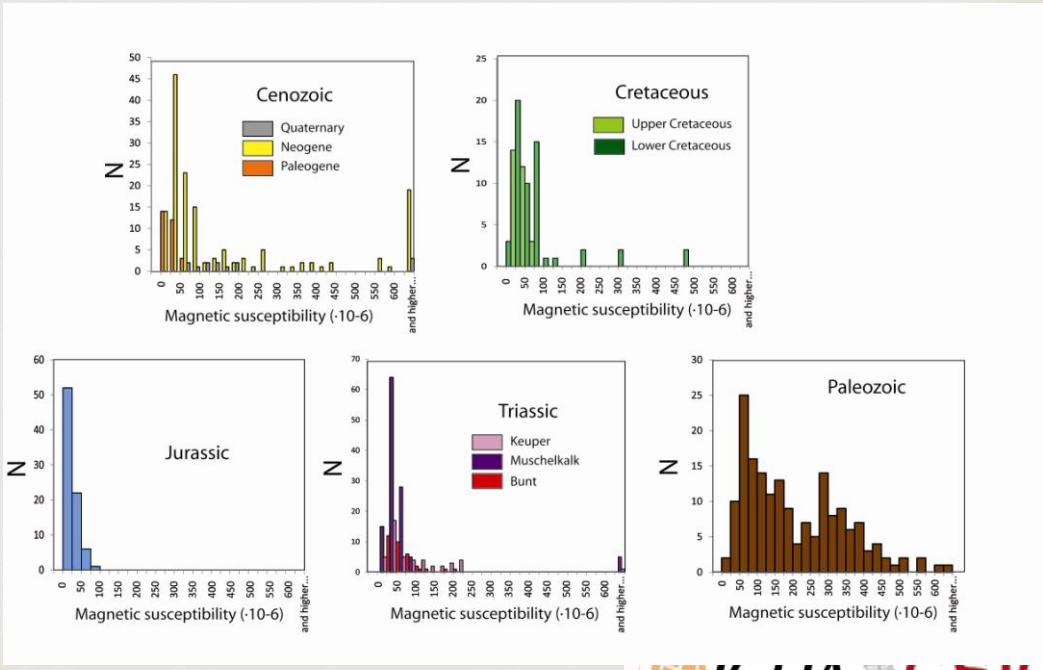
(uncertainty: ±0.02 g/cm3)

	Density (g/cm3)	Susceptibility (SIx10-6)
Q	1.8	0
Cz	2.4 (2.25)	60
Cr	2.56	45
Ju	2.62	10
K	2.25	60
B_M	2.57 (2.52)	60
Basement	2.68 (2.65)	300 (0-1370)



Magnetic susceptibility (SIx10-6)

(uncertainty: ±5 SIx10-6)



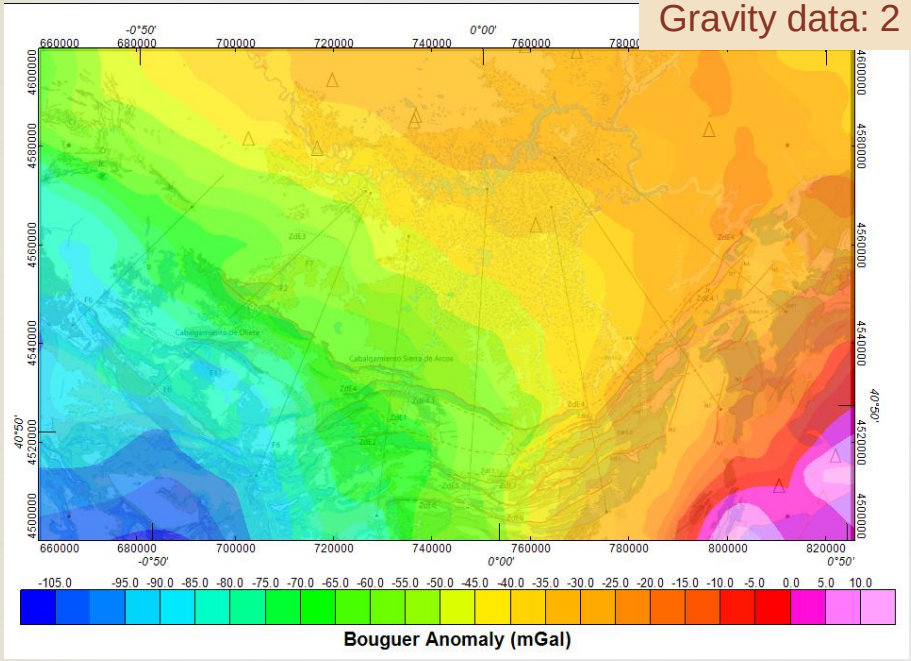
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

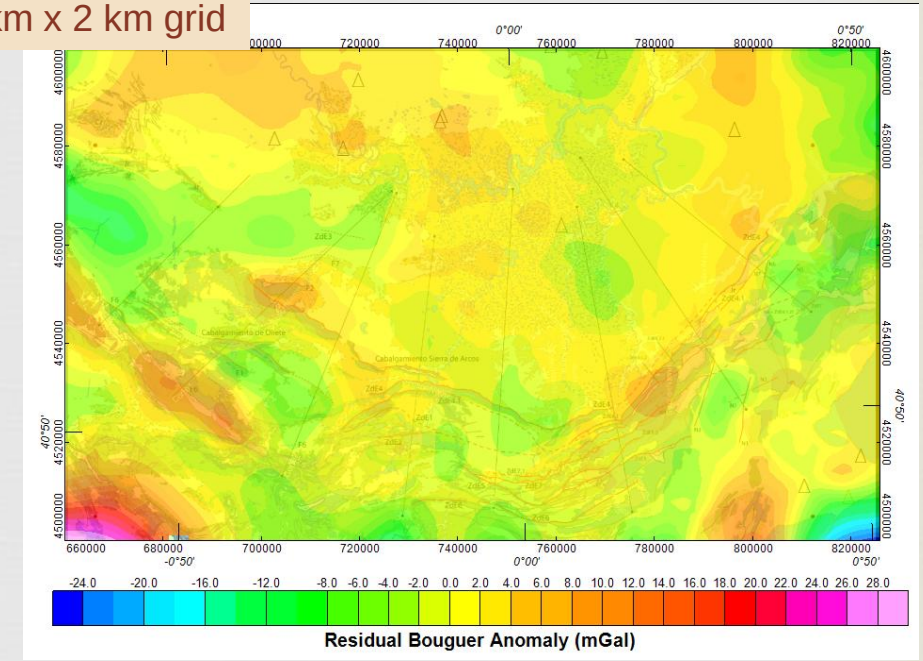
Instituto Geológico y Minero de España

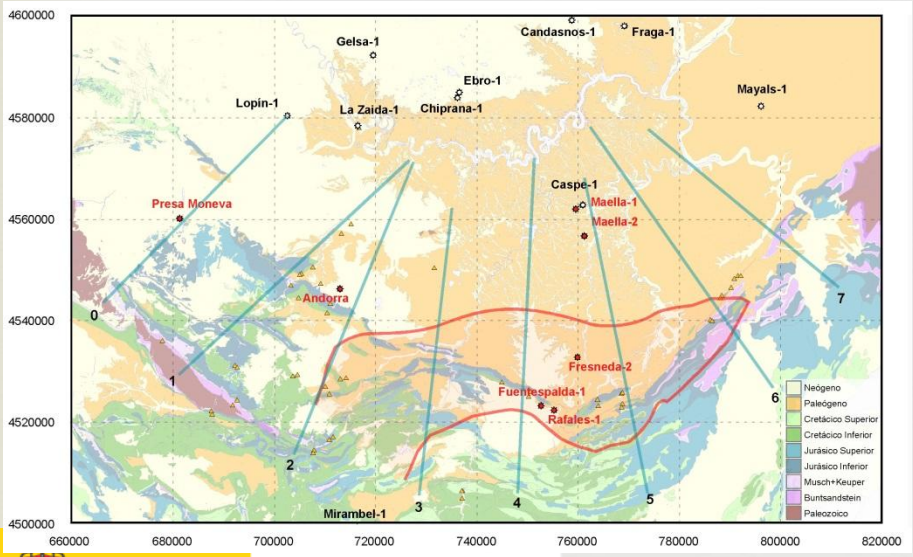
ICTJA CSIC

Geophysical data

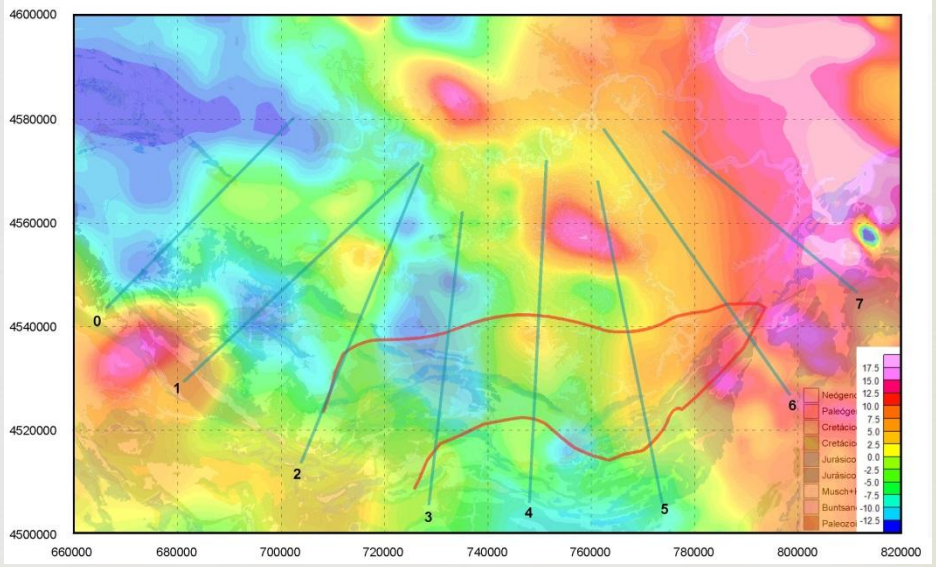
Gravity data: 2 km x 2 km grid







Drillholes

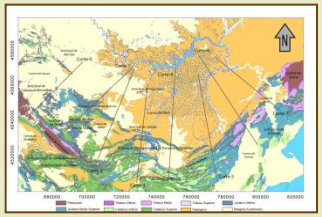


Total magnetic field (nT); 1km x 1km grid

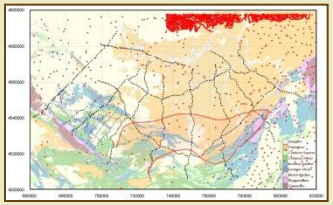
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

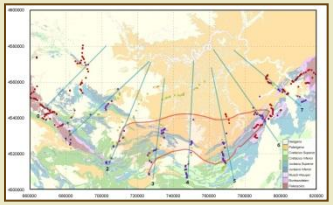
2.5D Modelling (1/2)



Field Mapping

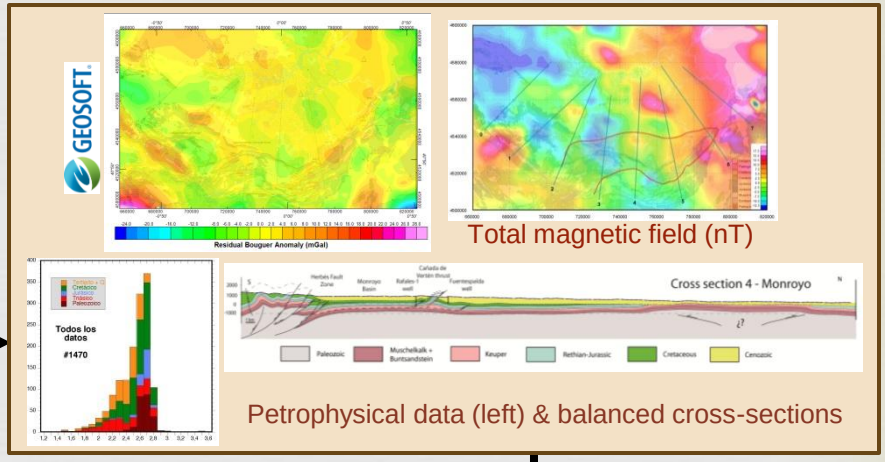


Grav and mag data
(surveys & IGME database)



Rock samples
(from succesive surveys)

- *Data processing*
- *Regional-residual separation*
- *Rock sample analysis*



Total magnetic field (nT)

Petrophysical data (left) & balanced cross-sections

- 8 cross-sections from 48.5 to 66 km in length

- RMS of the *errors* (observed-calculated):

Gravity modelling: c. 0.5 mGal
Magnetic modelling: c. 0.4nT

2.5D Forward GravMag Modelling

Final balanced cross-sections (*uncertainty in depth c. tens of m; sensitivity tests*)

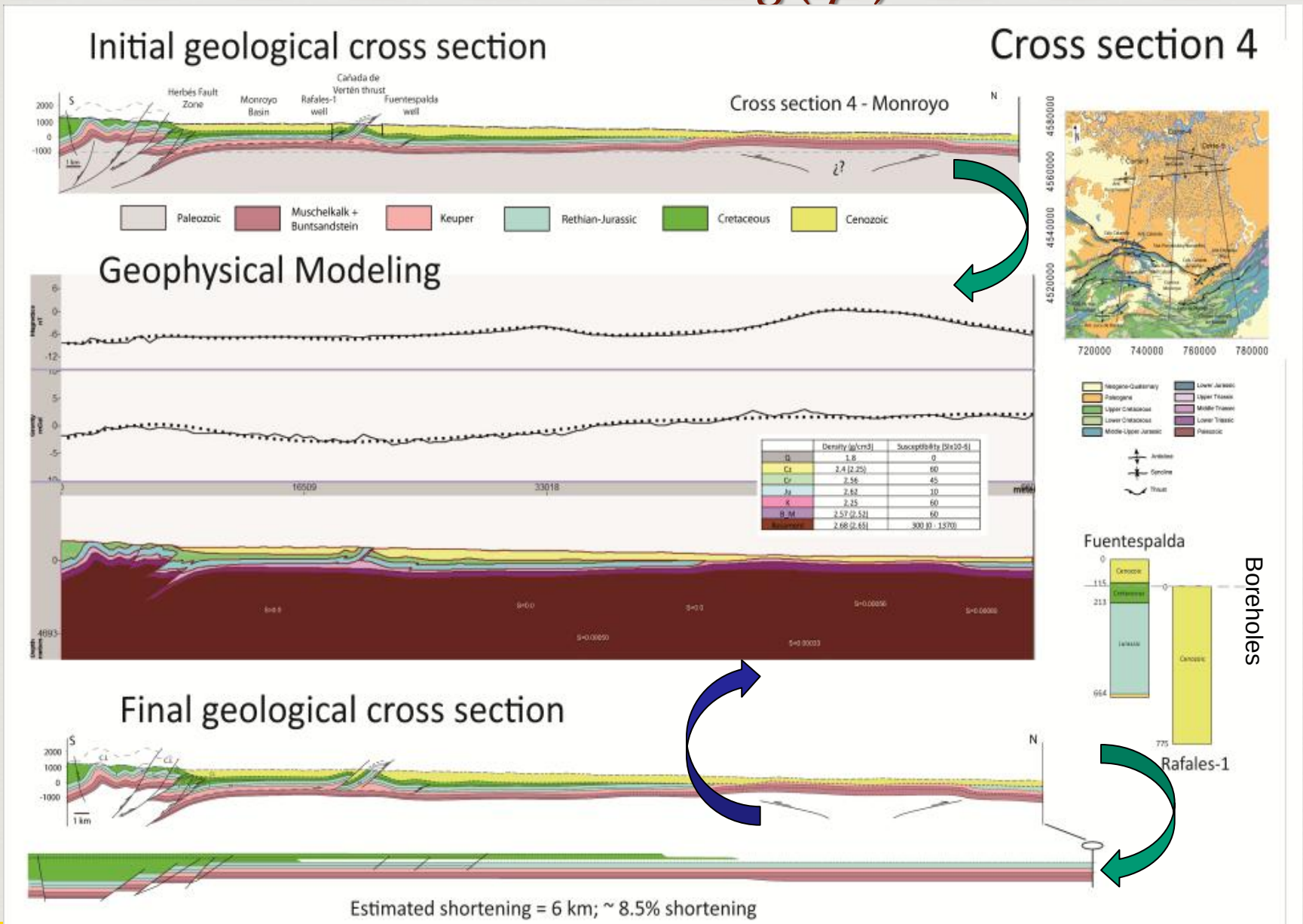
3D

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

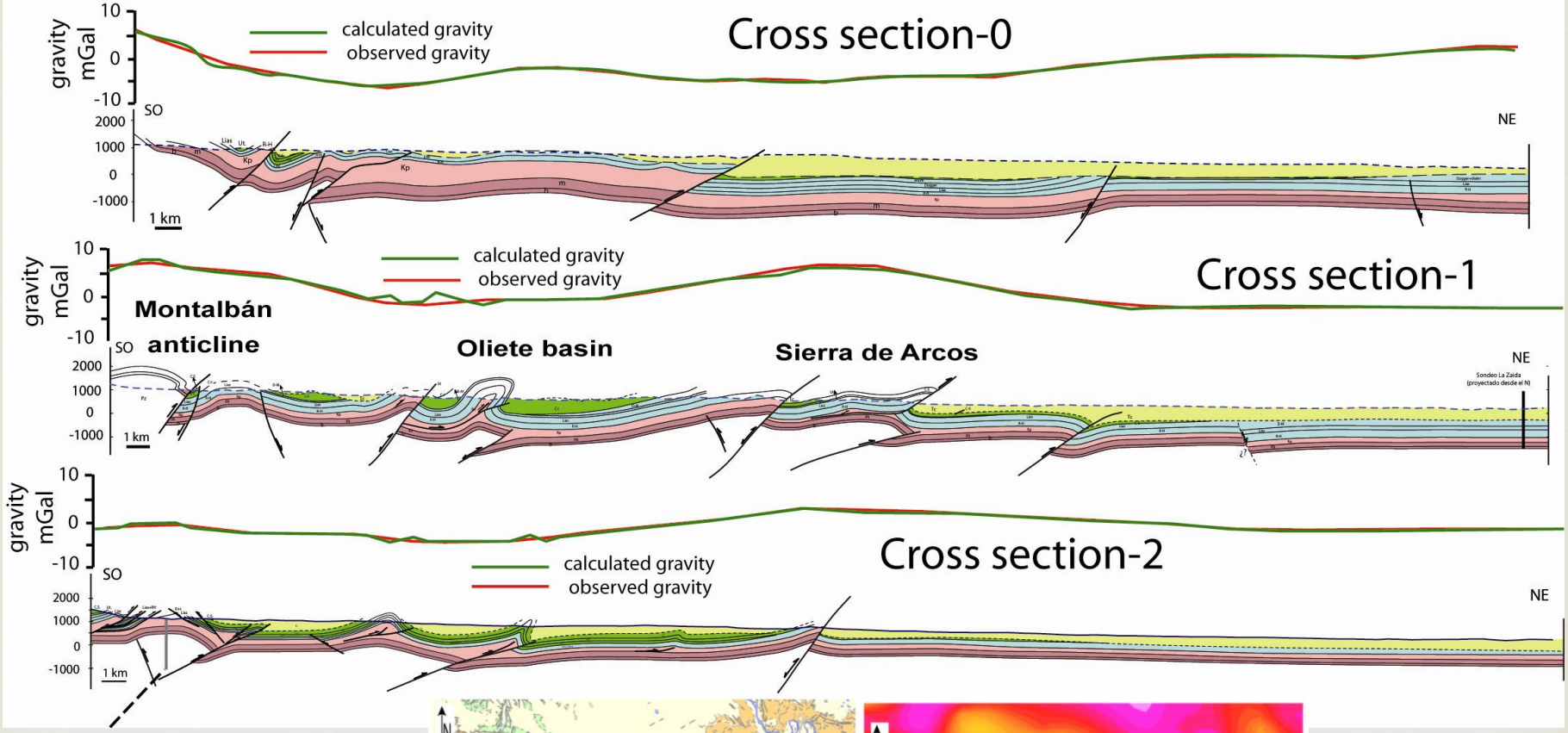
ICTJA CSIC

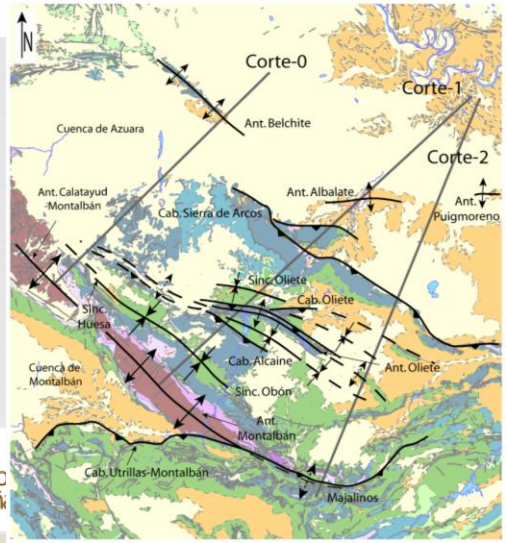
2.5D Modelling (2/2)

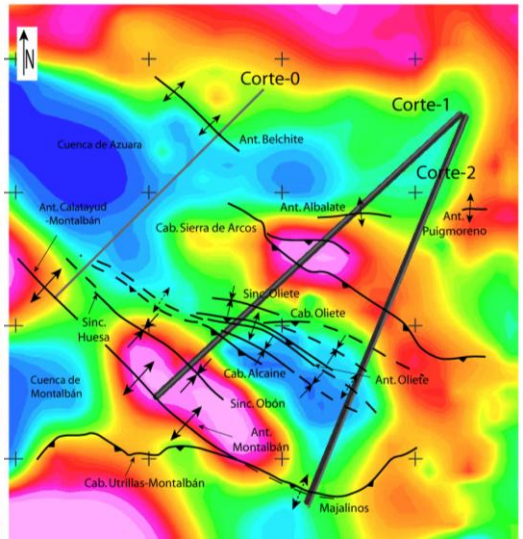


MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Instituto Geológico y Minero de España
ICTJA CSIC

WESTERN ARAGONIAN BRANCH: CROSS SECTIONS 0-2







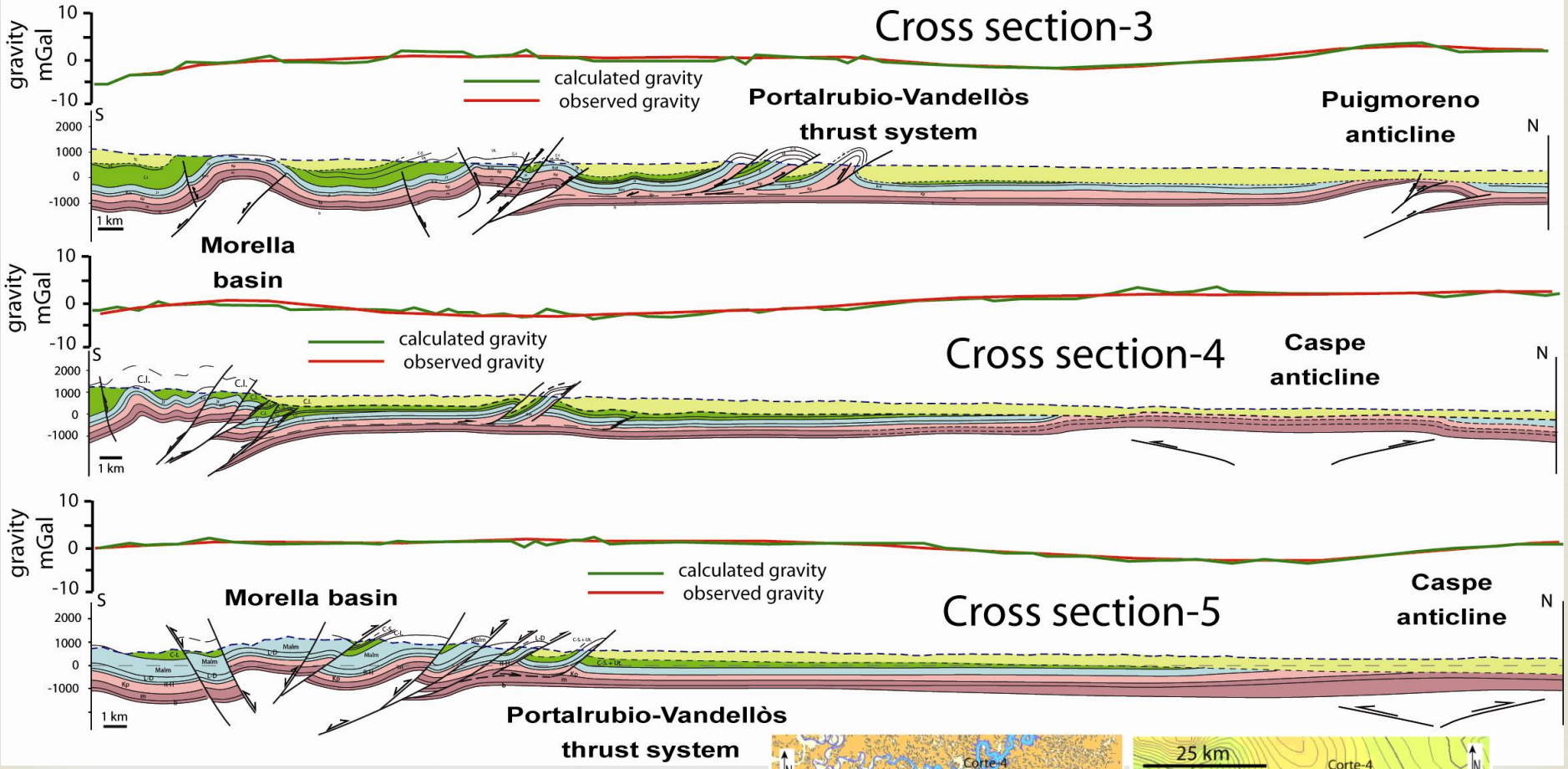
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

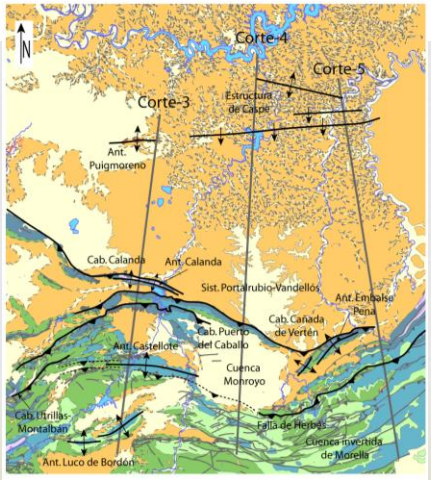
Instituto Geológico y Minero de España

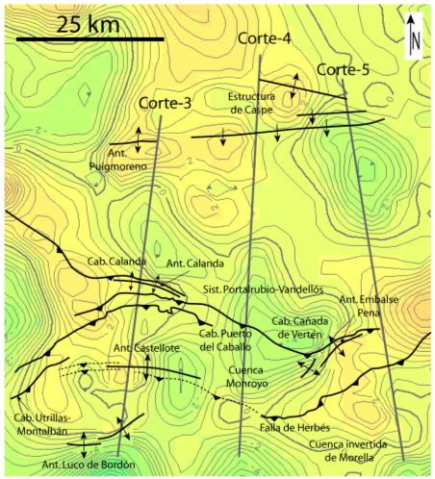
CTJA

CSIC

LINKING ZONE: CROSS SECTIONS 3-5





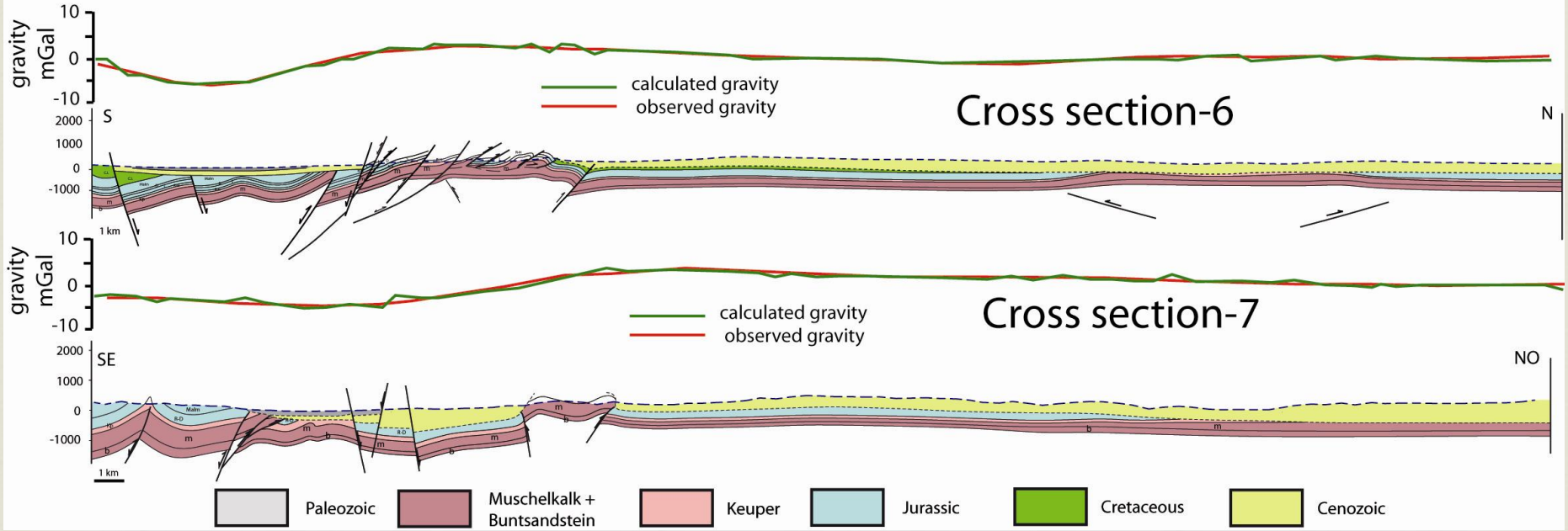


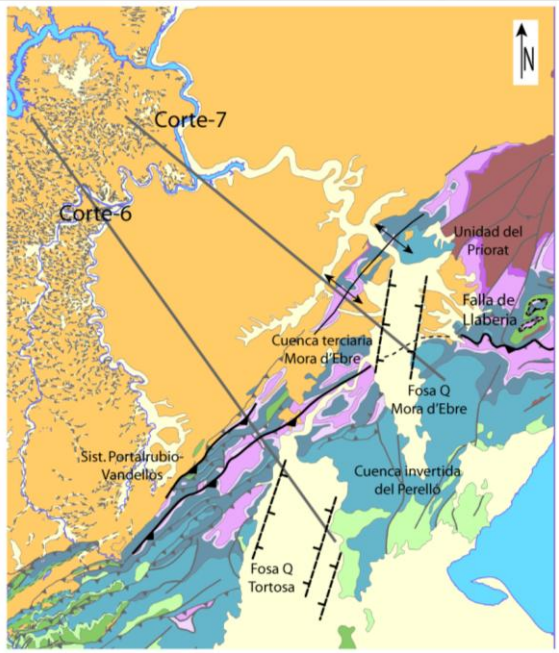
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

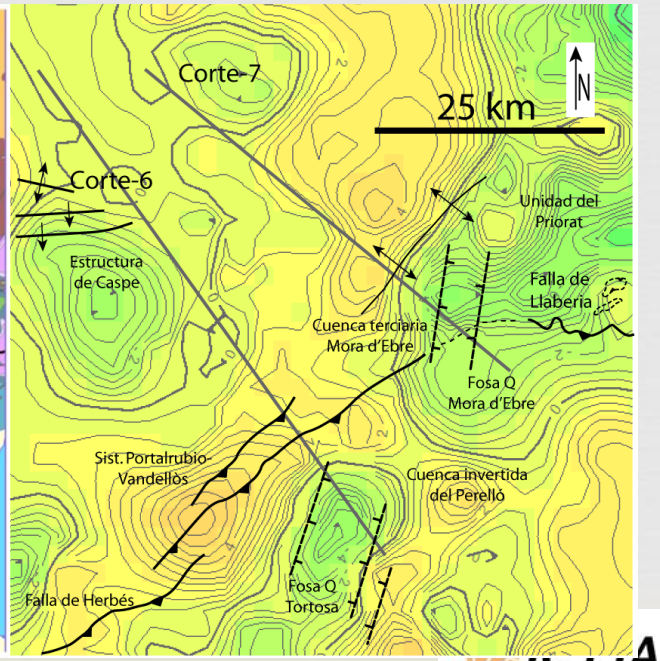
Instituto Geológico y Minero de España

SIC

CATALAN COASTAL RANGE: CROSS SECTIONS 6-7







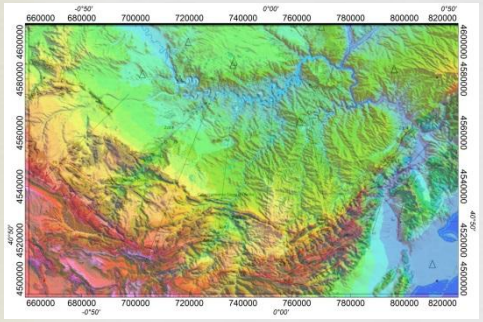
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

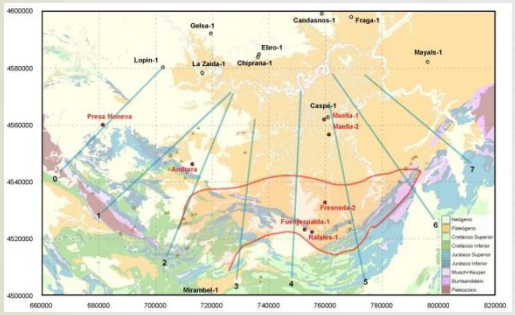
Instituto G... y Minero d... España

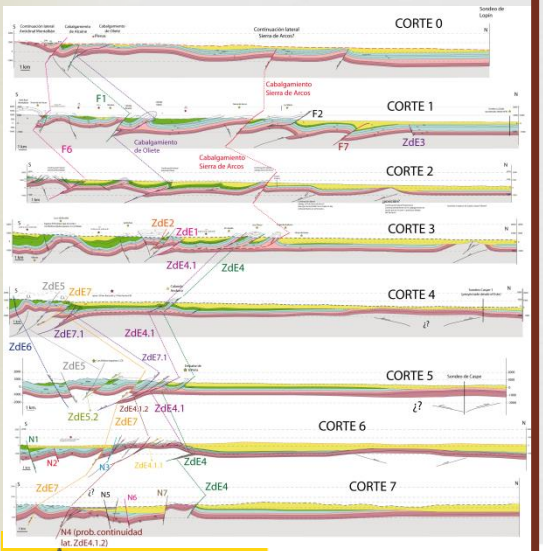
ICTJA

CSIC

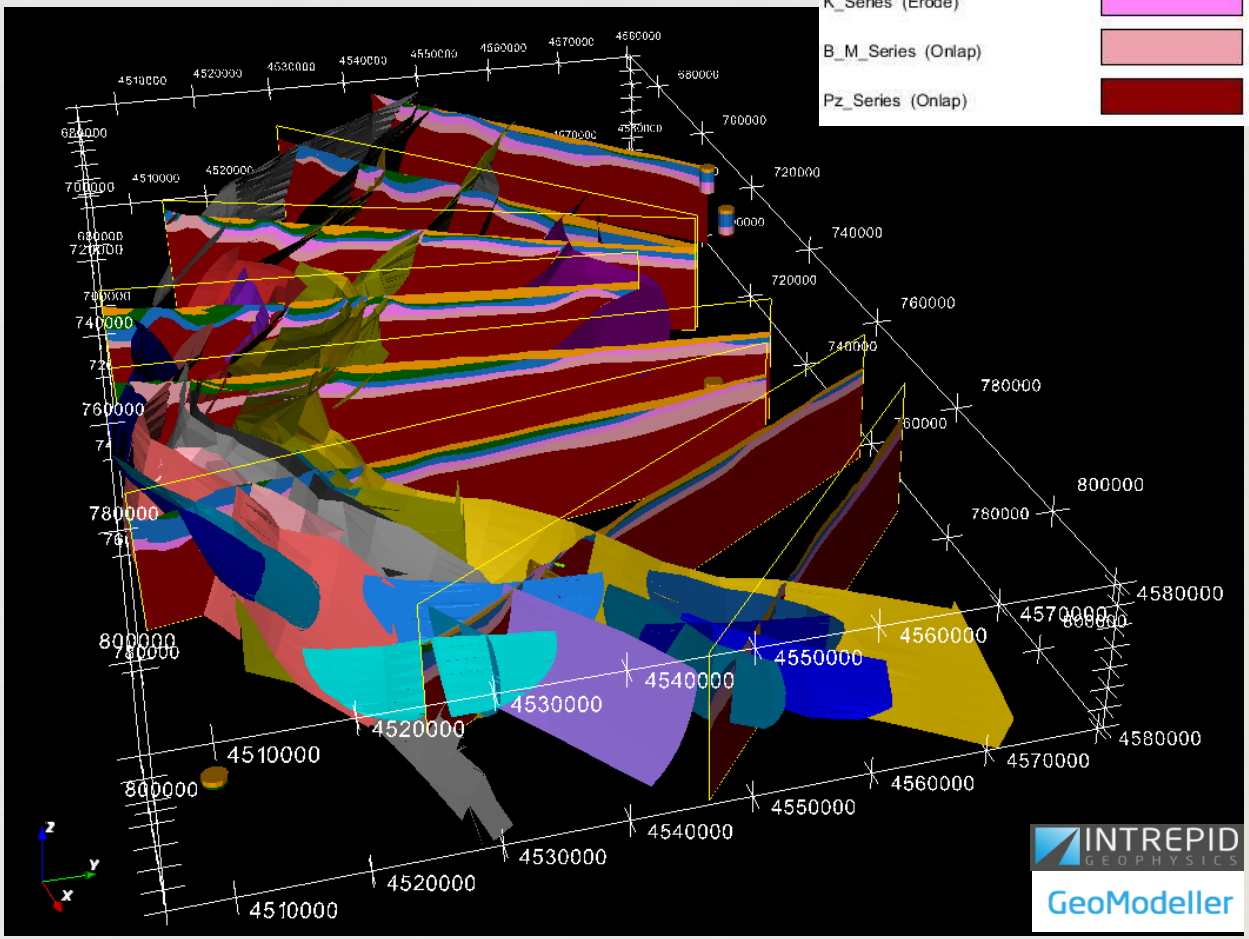
3D Modelling







Initial 3D geological model from DTM, surface geology (faults, dips, contacts), drillholes & balanced cross-sections from 2.5 D geophysical modelling



Stratigraphic pile

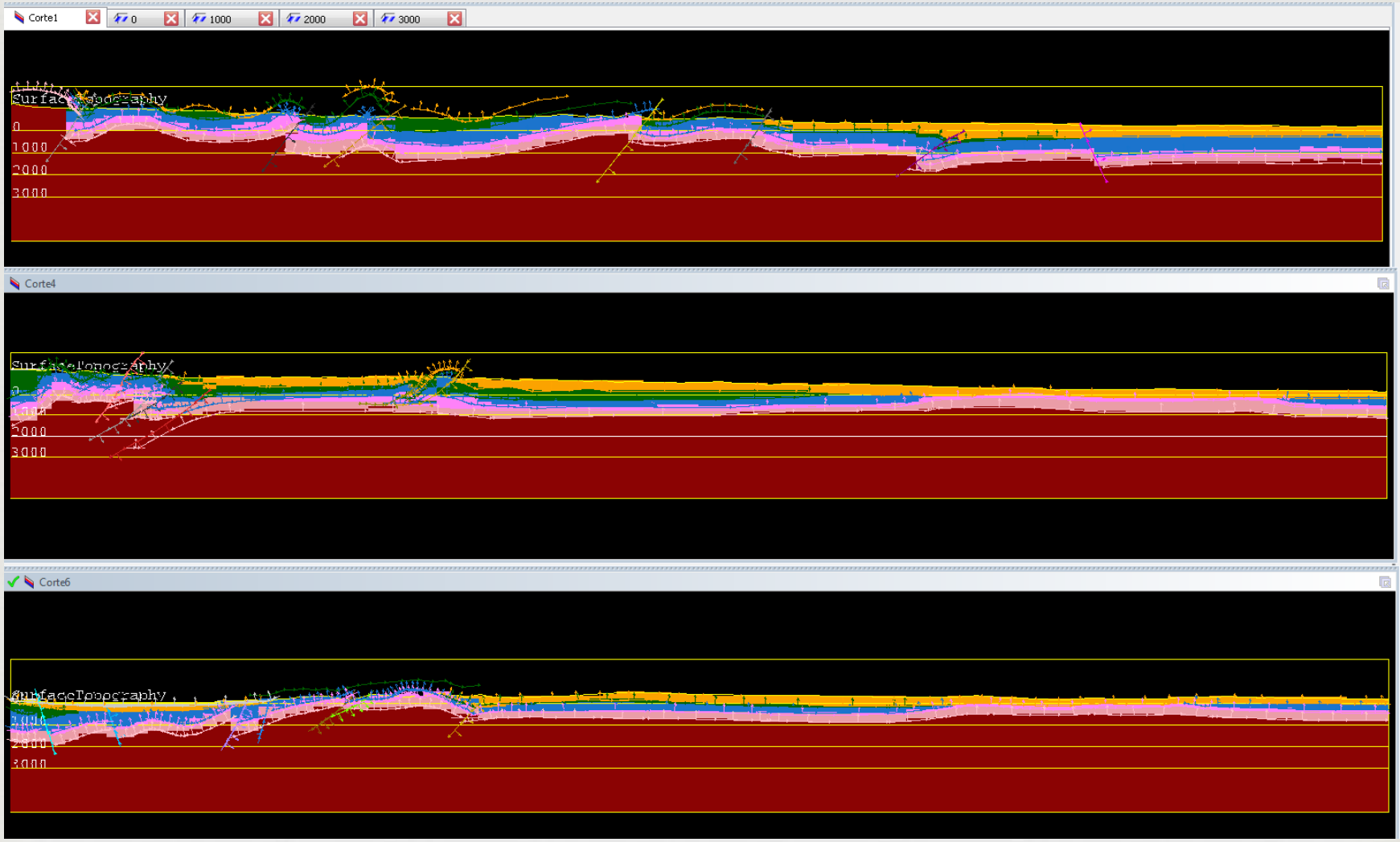
Reference: Bottom	
Q_Series (Erode)	Q
Cz_Series (Erode)	Cz
Cr_Series (Onlap)	Cr
Ju_Series (Onlap)	Ju
K_Series (Erode)	K
B_M_Series (Onlap)	B_M
Pz_Series (Onlap)	Pz

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

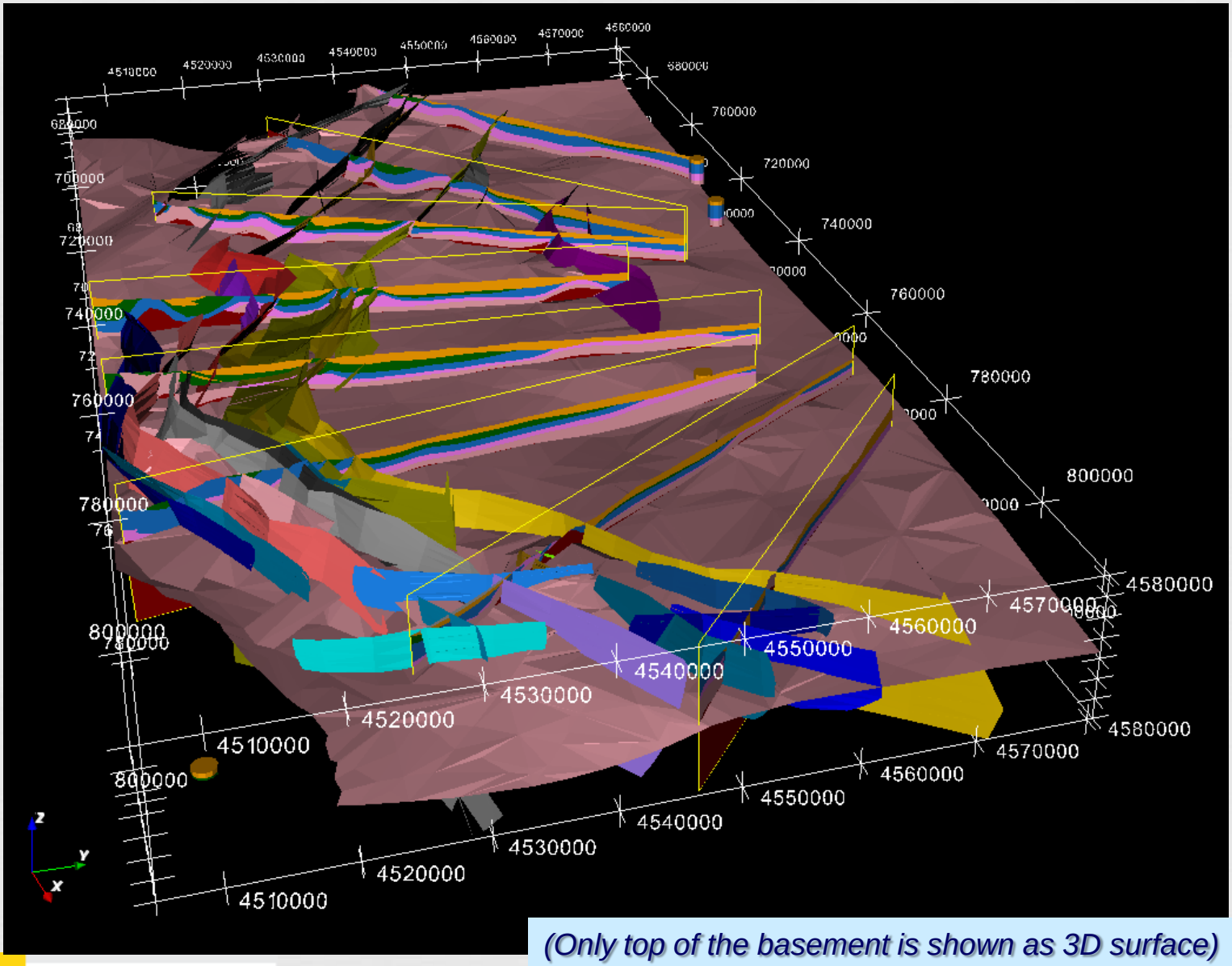
Instituto Geológico y Minero de España

ICTJA CSIC

3D initial model

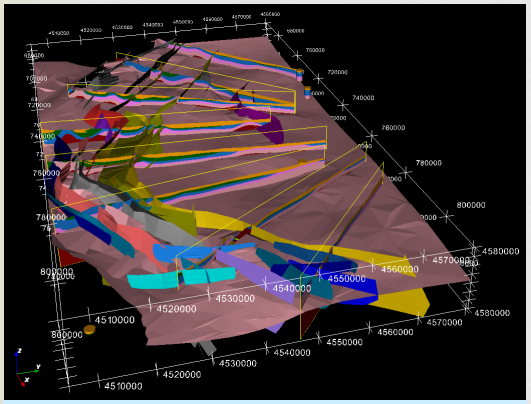


3D initial model

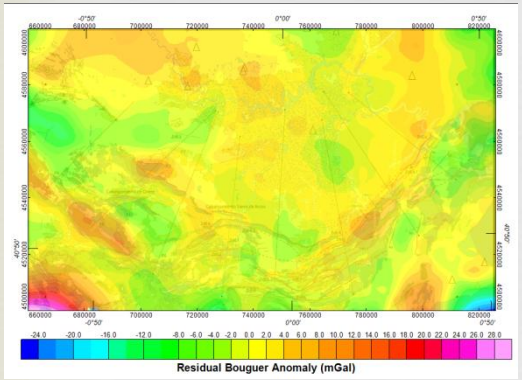


(Only top of the basement is shown as 3D surface)

3D Gravity Inversion



(Only top of the basement is shown as 3D surface)



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

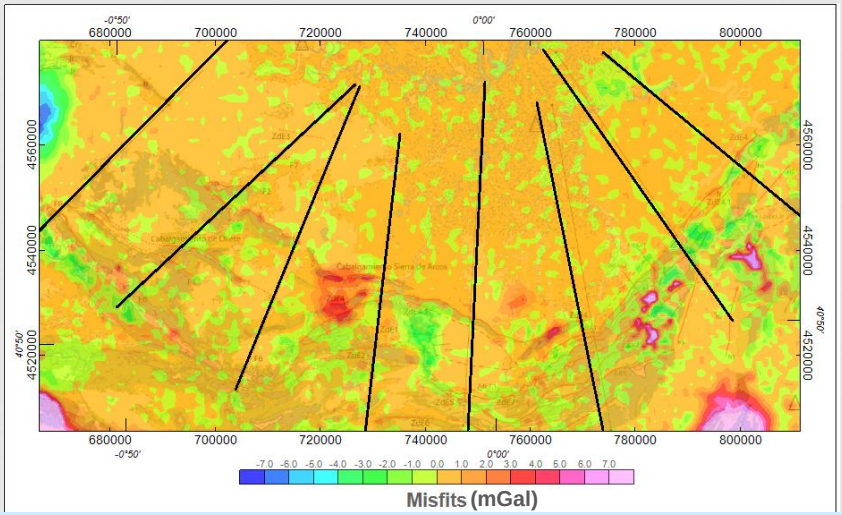
Density

Reference Density (g/cm³) 2.67

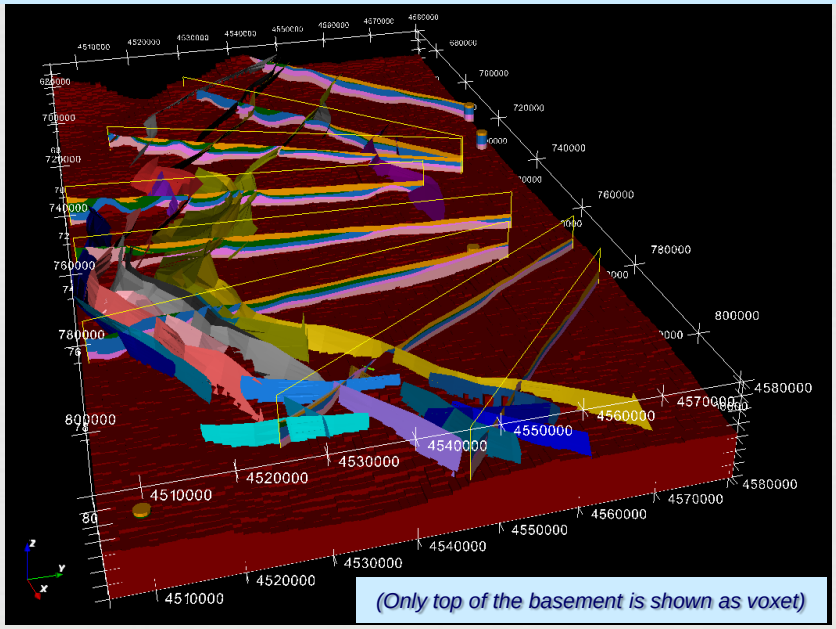
INTREPID GEOPHYSICS

GeoModeller

Stochastic gravity inversion



Uncertainty as probabilities (90% in this case)



(Only top of the basement is shown as voxet)

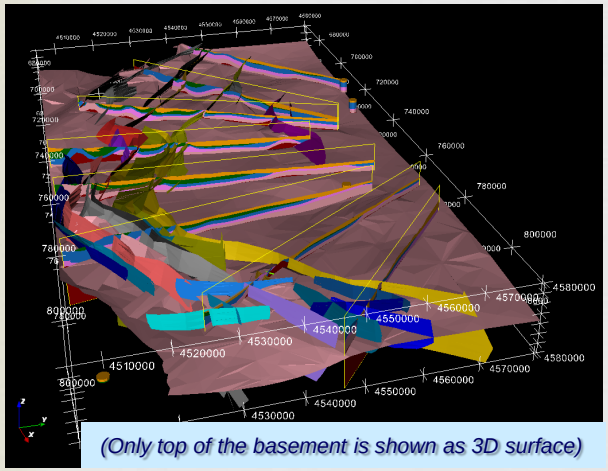
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

ICTJA CSIC

Stochastic gravity inversion

INTREPID GEOPHYSICS
GeoModeller



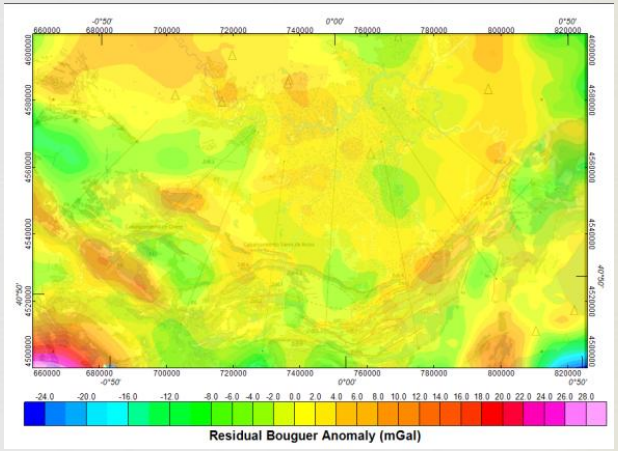
(Only top of the basement is shown as 3D surface)

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

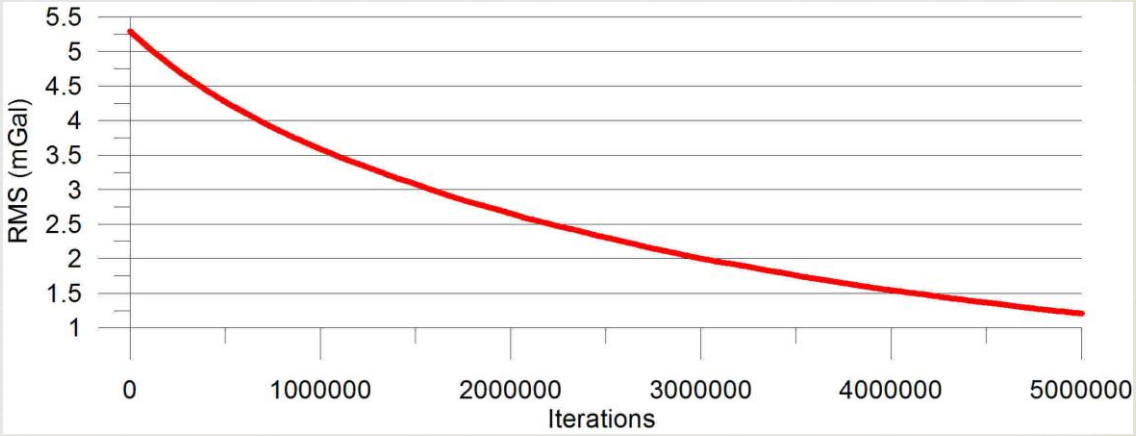
Reference Density (g/cm³) 2.67



Voxet:

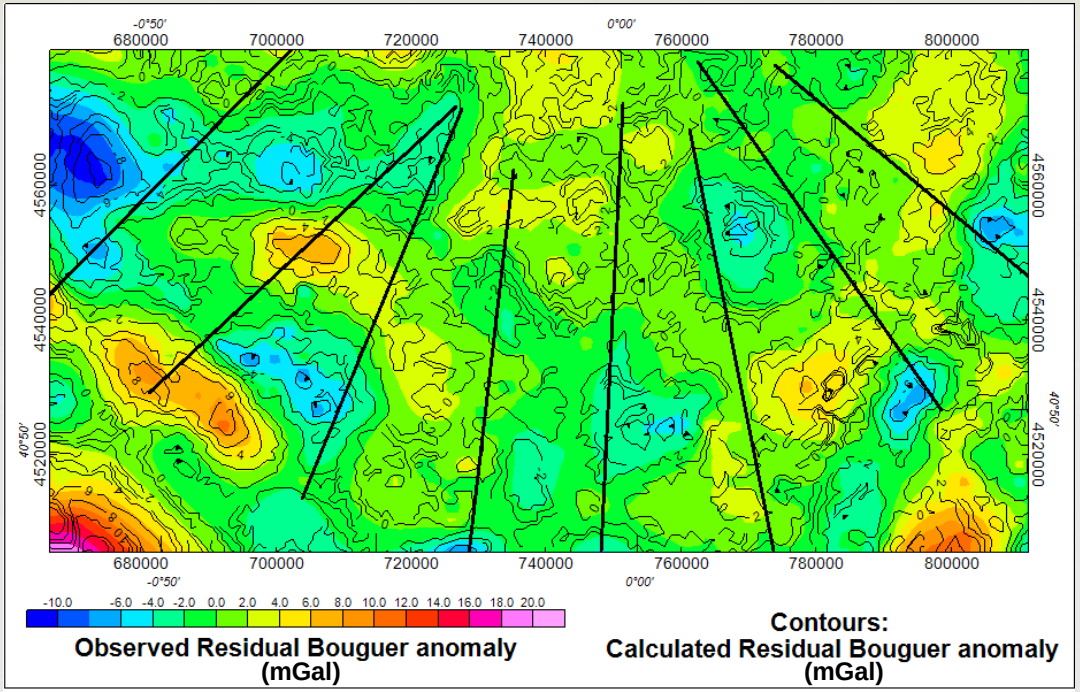
- 1000m x 1000 m x 50m
- 146 x 75 x 140 (1533000 voxels)

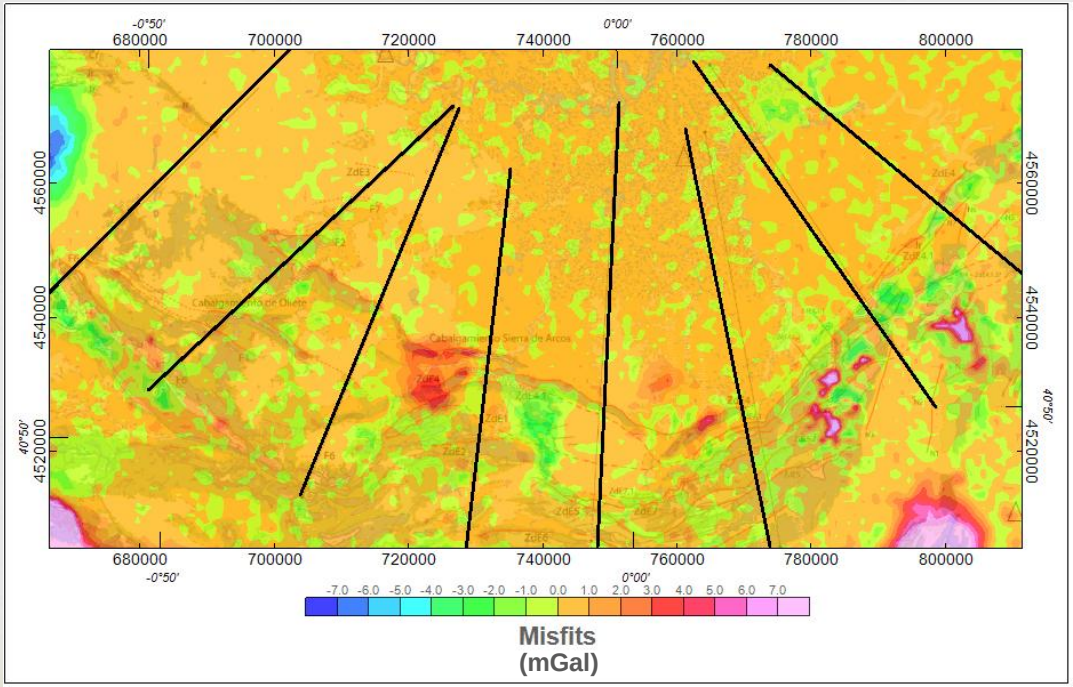
Threshold probability: 90%



MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Instituto Geológico y Minero de España
ICTJA CSIC

Results of the Inversion



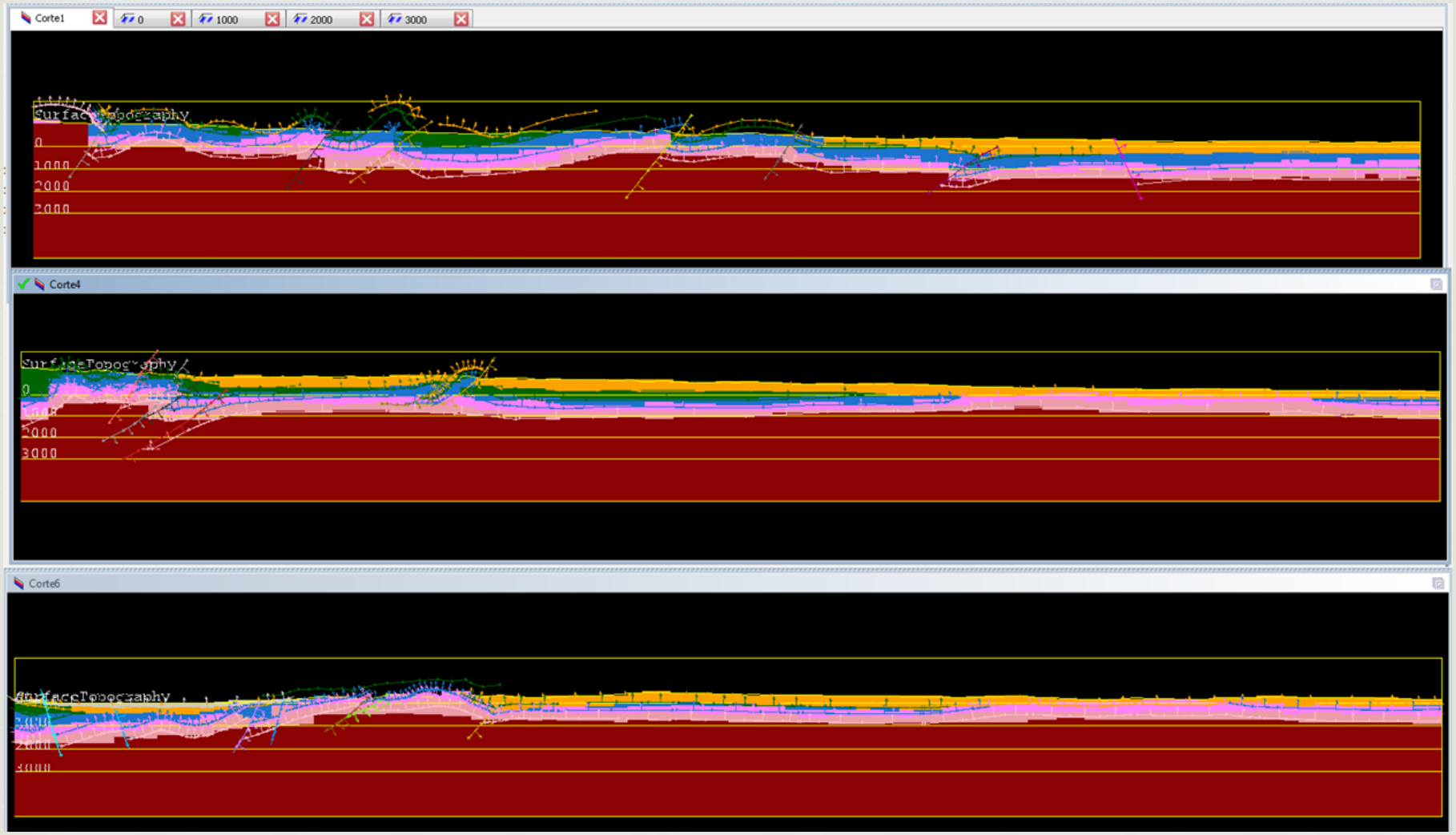


MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

CSIC

3D final model: Lithologies

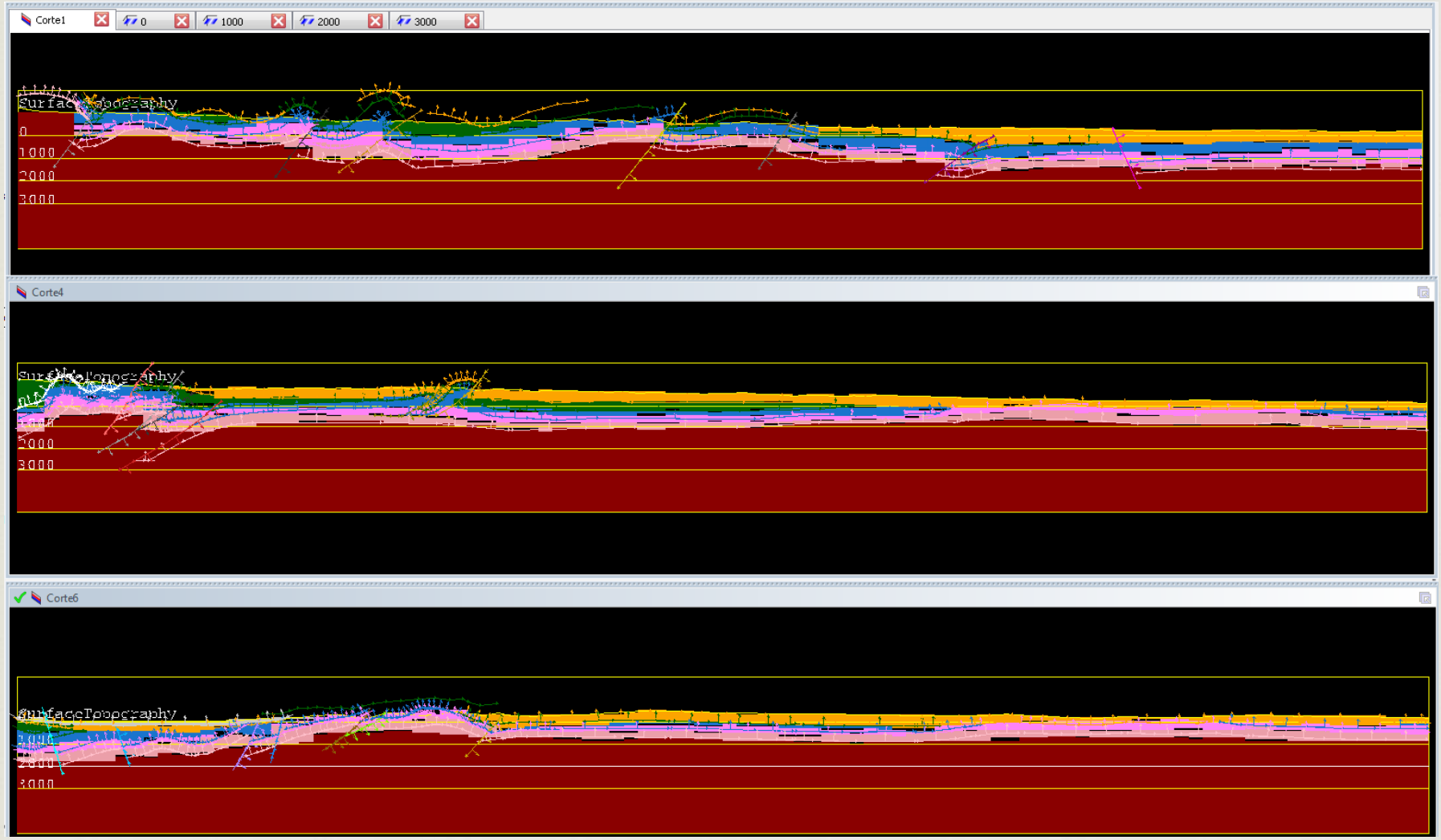


MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

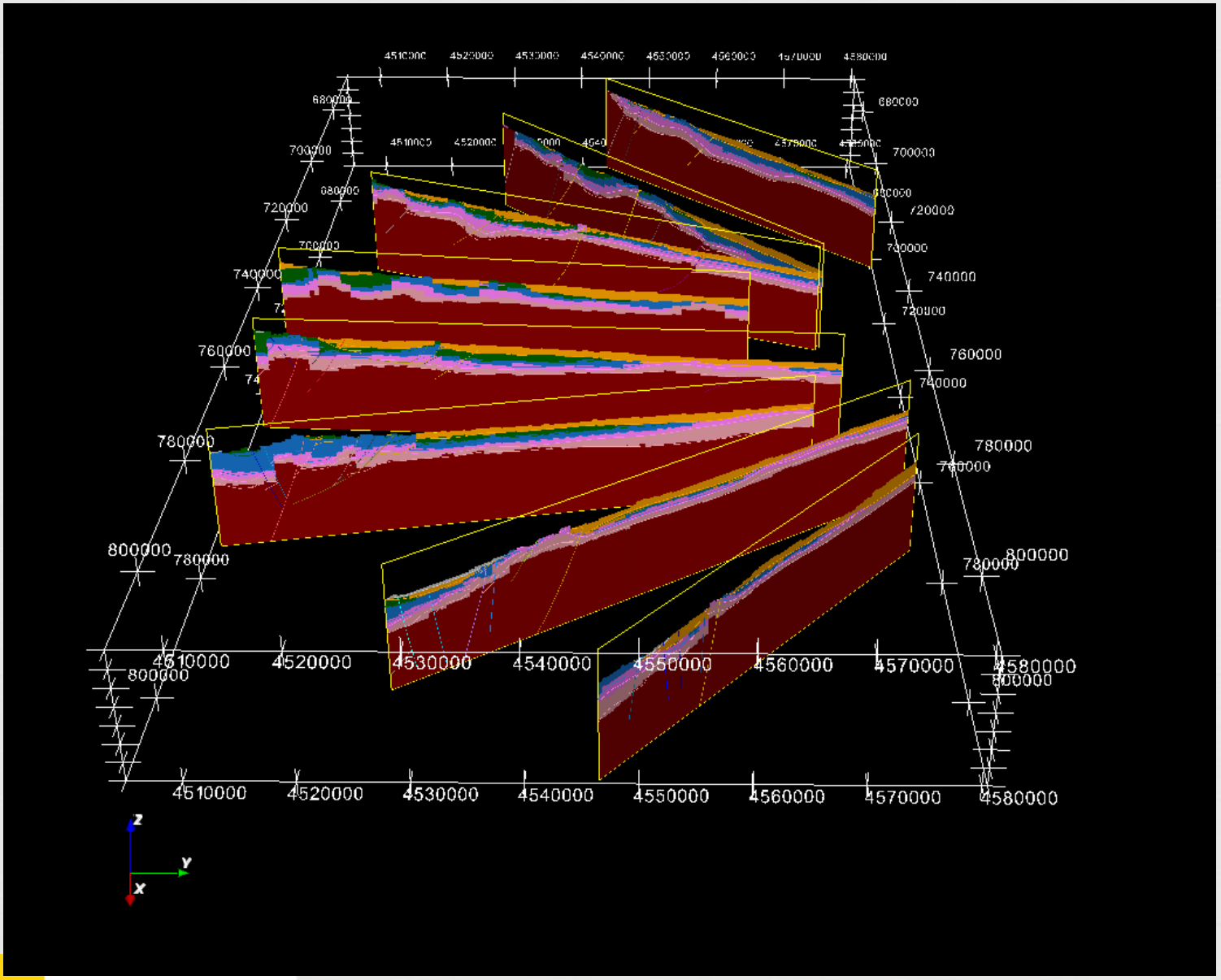
ICTJA CSIC

3D final model: Lithologies 90% probability

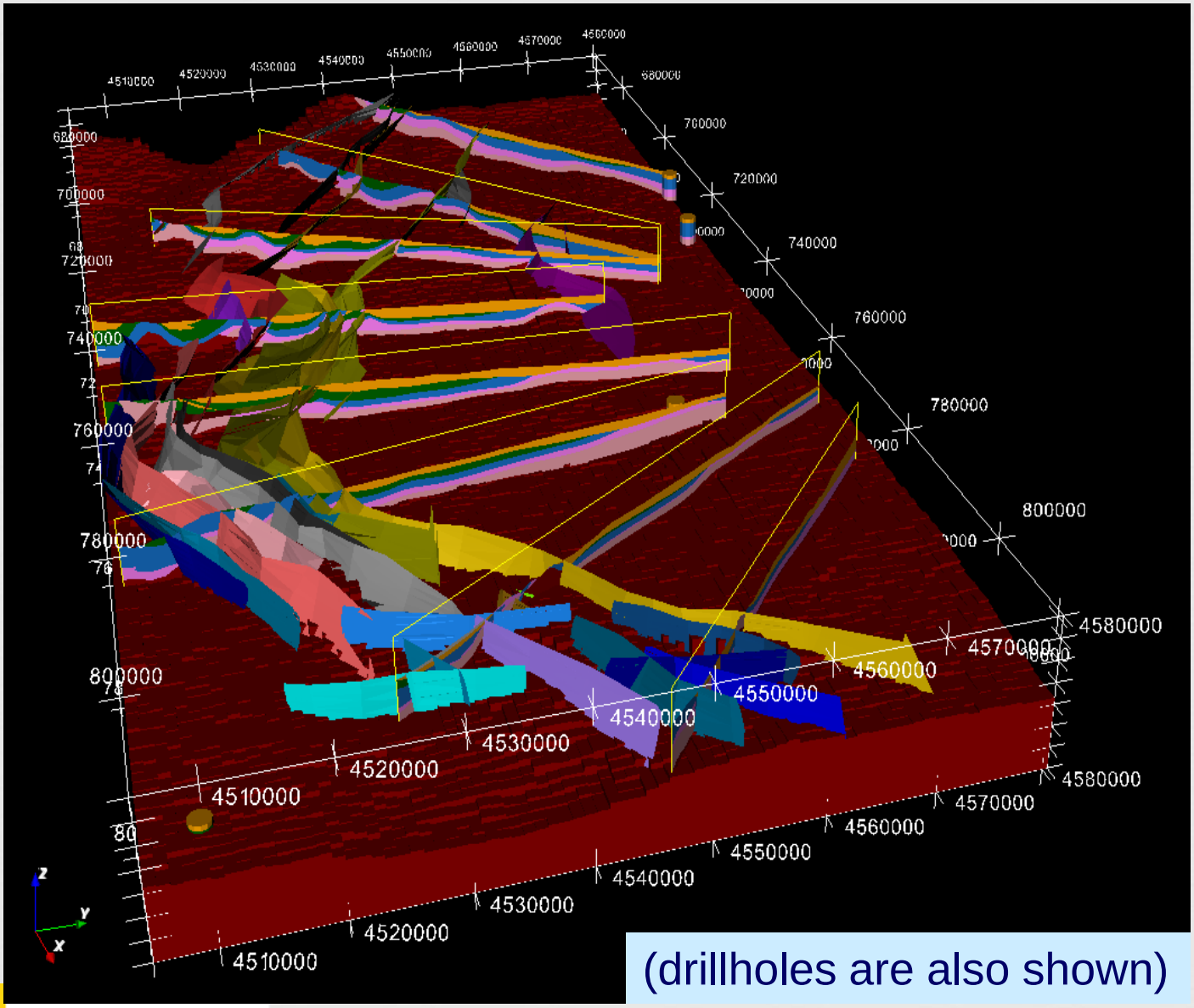


Uncertainties c. 50 to 100 m in depth (black voxels)

3D final model: Lithologies

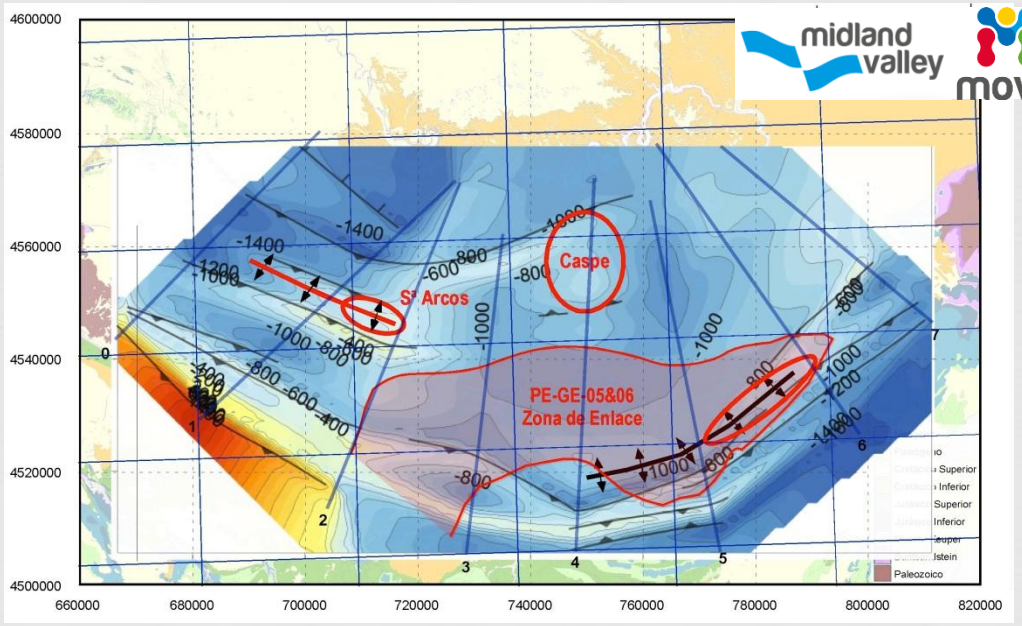


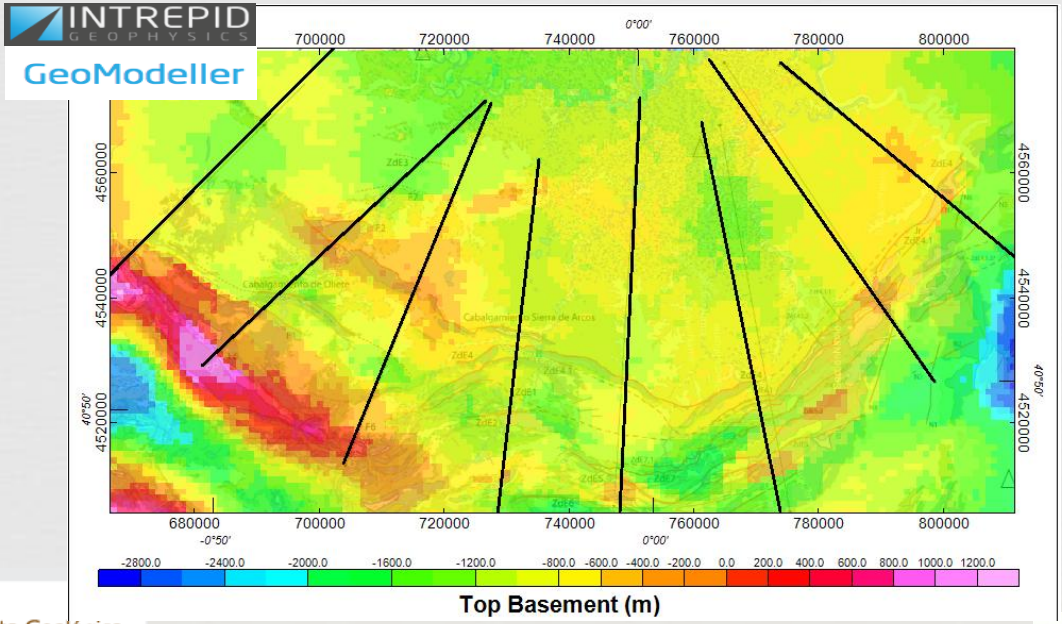
3D final model:
Basement voxet, sections and faults



(drillholes are also shown)

Consistency Move (from geology only) vs. Geomodeller (gravity inversion)





MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Instituto Geológico y Minero de España

ICTJA CSIC

Conclusions

- The presented workflow has allowed us to build up a 3D geological model with an uncertainty in depth of c. 100 m or less.

- The gravimetric inversion allows refining the geological model and better asses the uncertainty of the structures in depth.

- In the resulting geometry of the top of the basement we have identified two new anticline structures as potential CO2 reservoirs.

Acknowledgements:
Financial support for this study was received from the Spanish administration through the Instituto para la Reestructuración de la Minería del Carbón y el Desarrollo Alternativo de las Comarcas Mineras (IRMC).

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Instituto Geológico y Minero de España
ICTJA CSIC