Tectono-Sedimentary Evolution of the Cotiella Salt Basins (South-Central Pyrenees of Spain)*

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Abstract

The Cotiella thrust sheet is a major structural unit of the South-Central Pyrenees. It consists of inverted Late Cretaceous extensional basins, which developed in the Bay of Biscay-Pyrenean realm of the Atlantic Ocean during the opening of the Central Atlantic. The internal structure of the Cotiella thrust sheet is dominated by well preserved seismic-scale middle Coniacian - early Santonian shallow-dipping extensional listric growth faults detached over Upper Triassic evaporites, displaying spectacular rollover anticlines in their hangingwalls. The Cotiella extensional basins were only partially inverted during the Pyrenean orogeny, although transported for 10's of kilometres southwards.

The Cotiella basins are interpreted to have been formed by gravity-driven extension and detachment of the post-rift platform above Upper Triassic evaporites, in a manner similar to that proposed for the salt basins of the Atlantic passive margins. The Cotiella basins developed at the transition from a shallow carbonate platform to the slope. As a result, the stratigraphic record preserves the tectono-sedimentary relationships between the different carbonate facies and the structural framework of the extensional system. The excellent exposures offer a unique opportunity to investigate in outcrop the carbonate systems that prograde over salt basins and gain insight into the understanding of the tectono-sedimentary evolution of the post-rift basins that at present are submerged in the Atlantic Ocean.

We provide new data to better understand the evolution of the Cotiella extensional basins. The structure of the basins has been investigated through geological mapping, integrated with detailed 1:5000 aerial ortophotographs. Cross-sections and detailed interpretations of oblique photographs are presented to describe the structural framework, the facies distribution, and the inversion of the extensional system. 1:5000 field cartography and a preliminary field-data-based 3D model have been elaborated to better constrain the cross-sections. New data indicates that salt tectonics played a significant role in the tectono-sedimentary architecture of the extensional basins, and a new geological model to constrain the evolution of the Cotiella salt basins is presented.

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OUTLINE

1) Regional setting
2) The Cotiella thrust sheet: structural setting
3) The Cotiella extensional system
4) Role of salt tectonics
5) Conclusions

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Statoil

1. Regional setting

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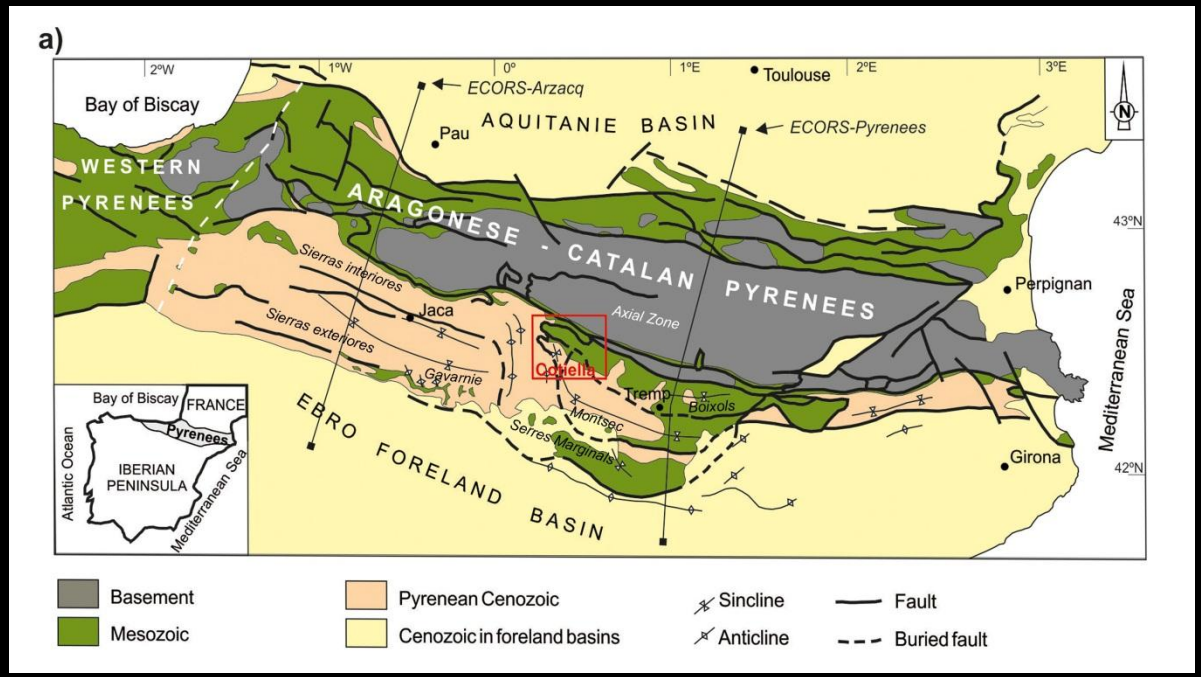
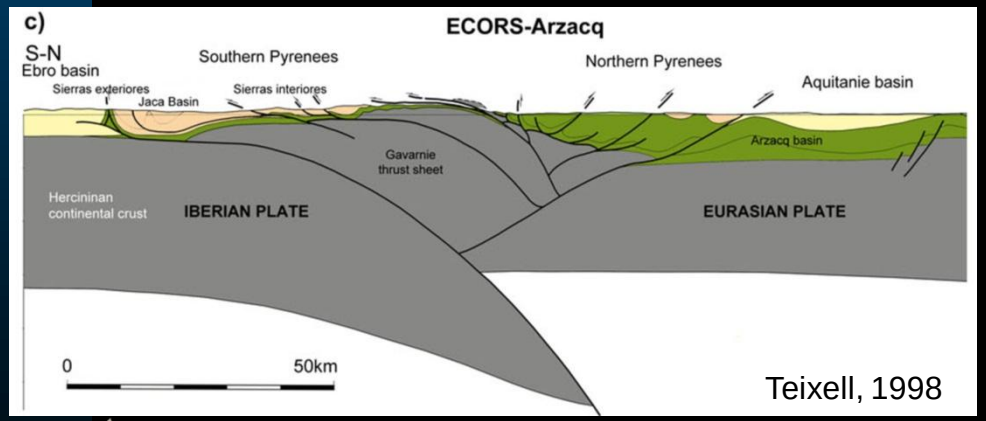
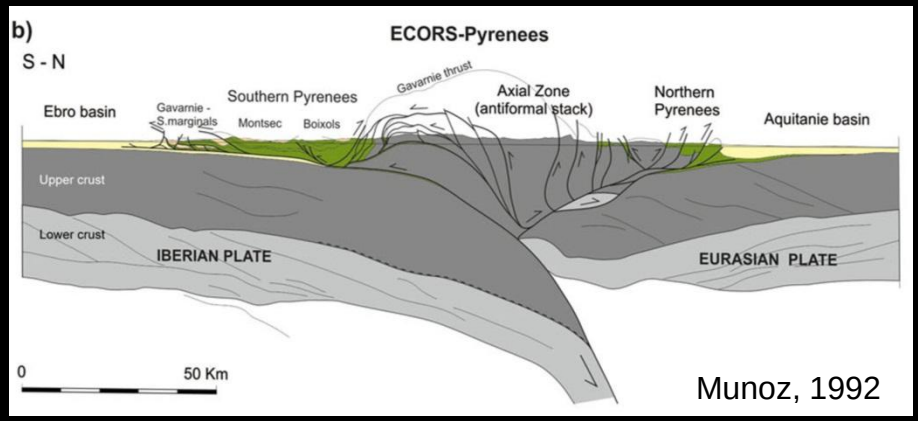
THE PYRENEES





Teixell, 1998



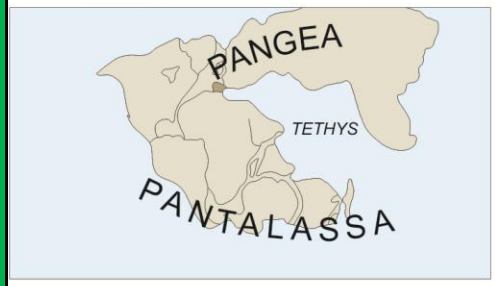
Munoz, 1992

1. Regional setting

DIVERGENCE

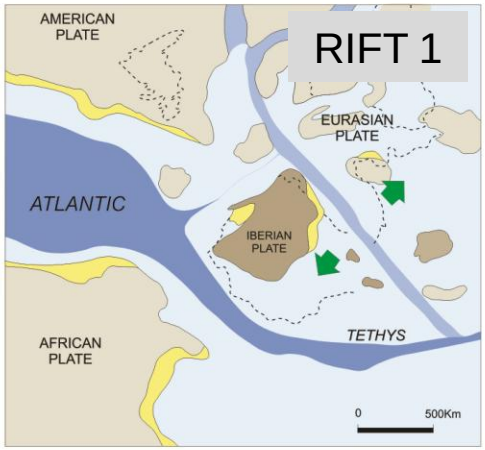
CONVERGENCE

LATE PALEOZOIC (305 M.y.).



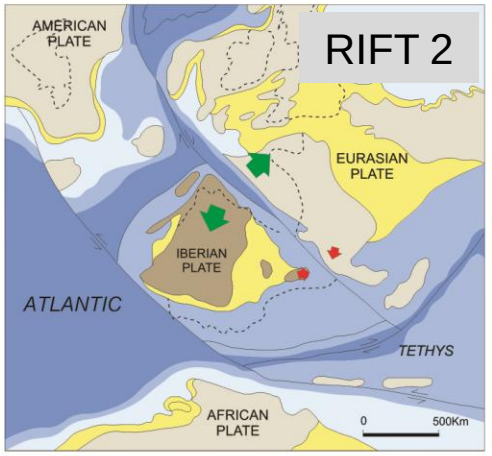
Modified from A. Nicolas, 1995

EARLY JURASSIC (145 M.y.)



Modified from Ziegler (1989)

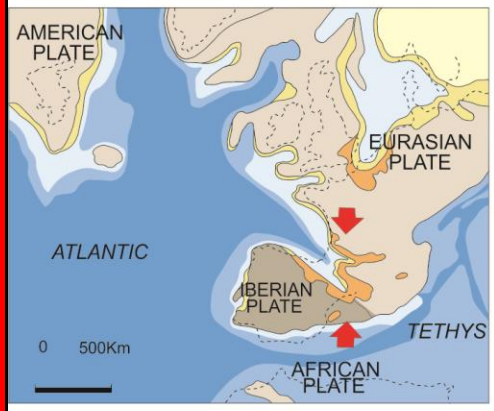
EARLY CRETACEOUS (100 M.y.)



Modified from Ziegler (1989)

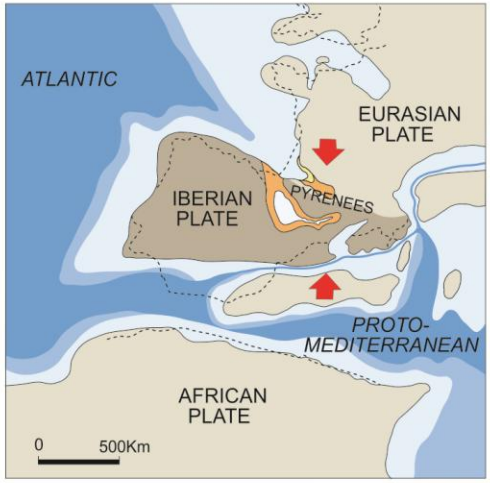
Pyrenean orogeny and inversion of the extensional basins

LATE CRETACEOUS (65 M.y.)

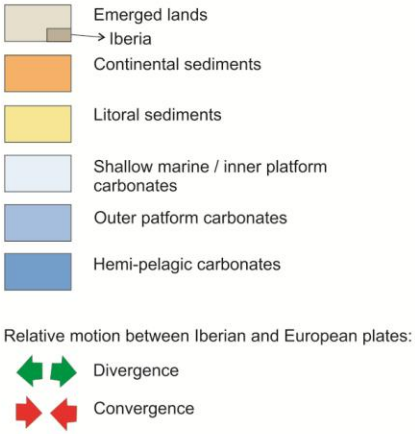


Modified from Ziegler (1989)

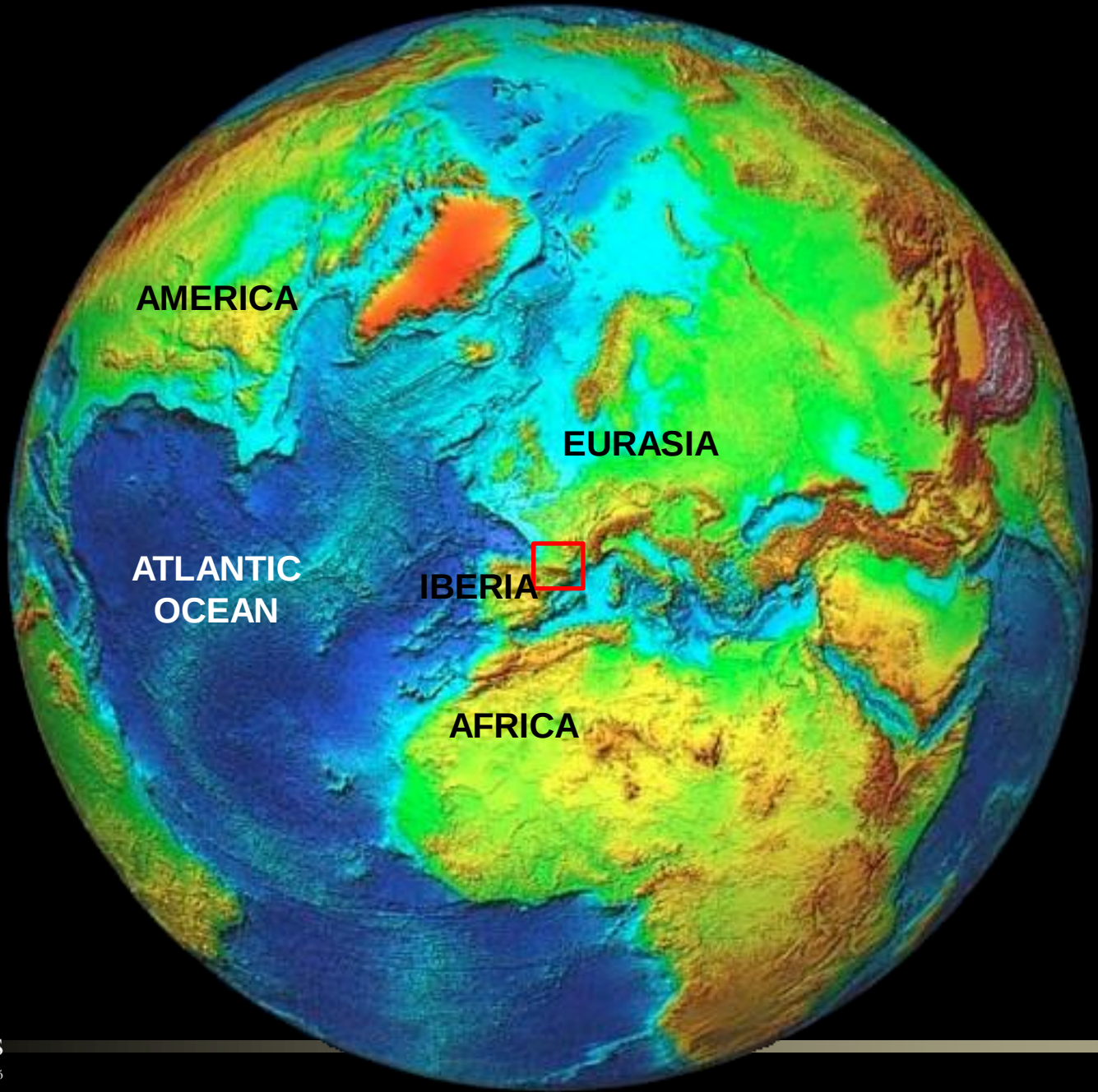
MIDDLE EOCENE (37 M.y.)



Modified from Santanach et al. (1986)



1. Regional setting



1. Regional setting

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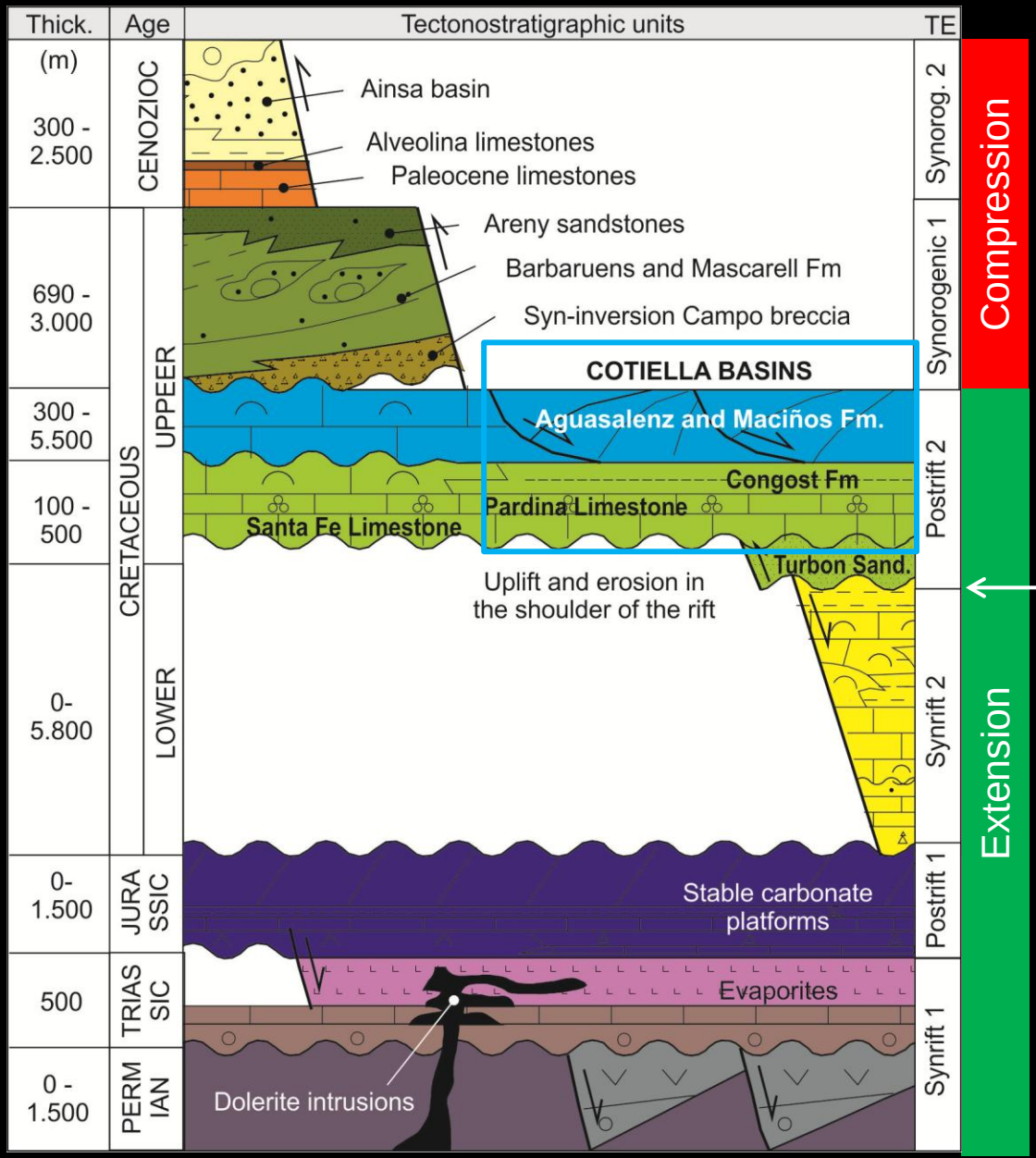
Chronostratigraphic diagram of the Southern Pyrenees



Nappe tectonics

Inversion of the extensional basins

Post-rift basins detached above relict Upper Triassic salt

Erosion of Jurassic and Early Cretaceous in the shoulder of the rift

Major rift event

Post-rift carbonate platforms

Syn-rift salt

Break-up of Pangea

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Modified from Garcia-Senz, 2002

1. Regional setting

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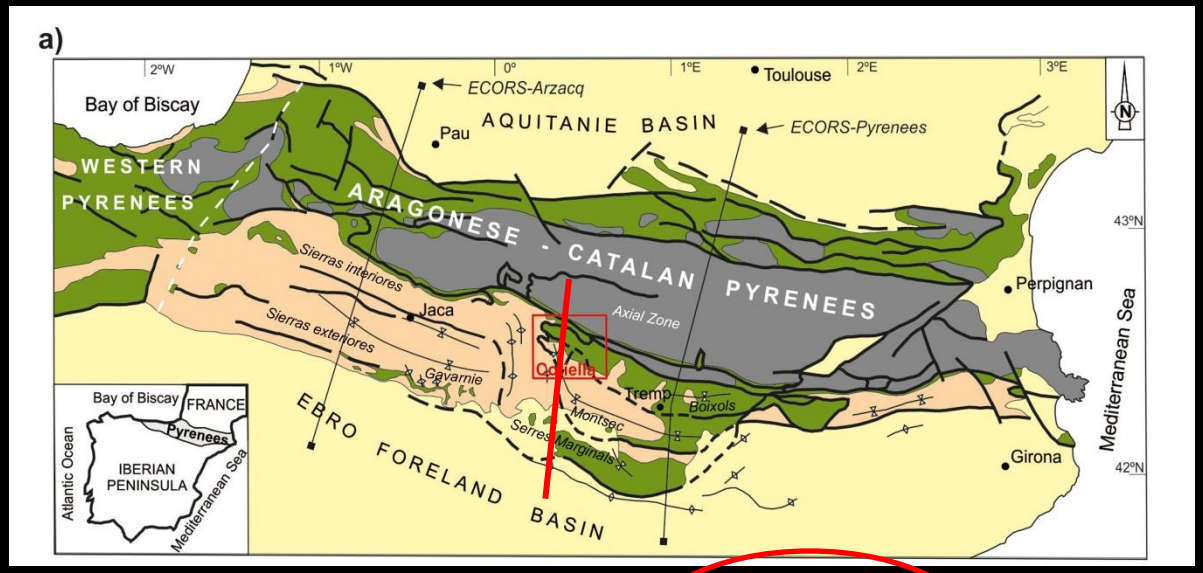
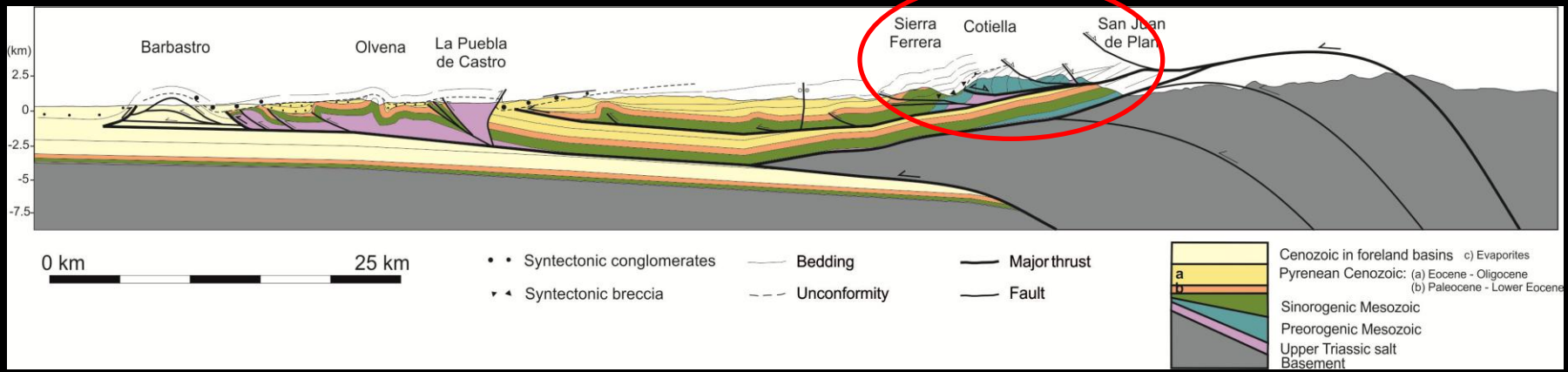
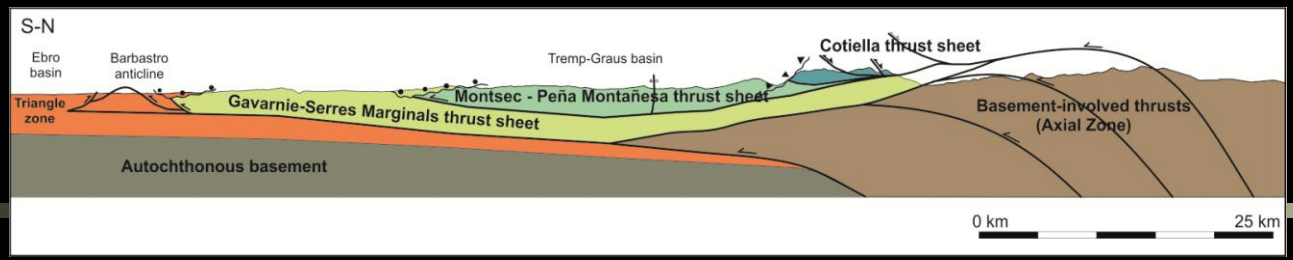
THE SOUTH –CENTRAL PYRENEES







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2. The Cotiella thrust sheet: structural setting

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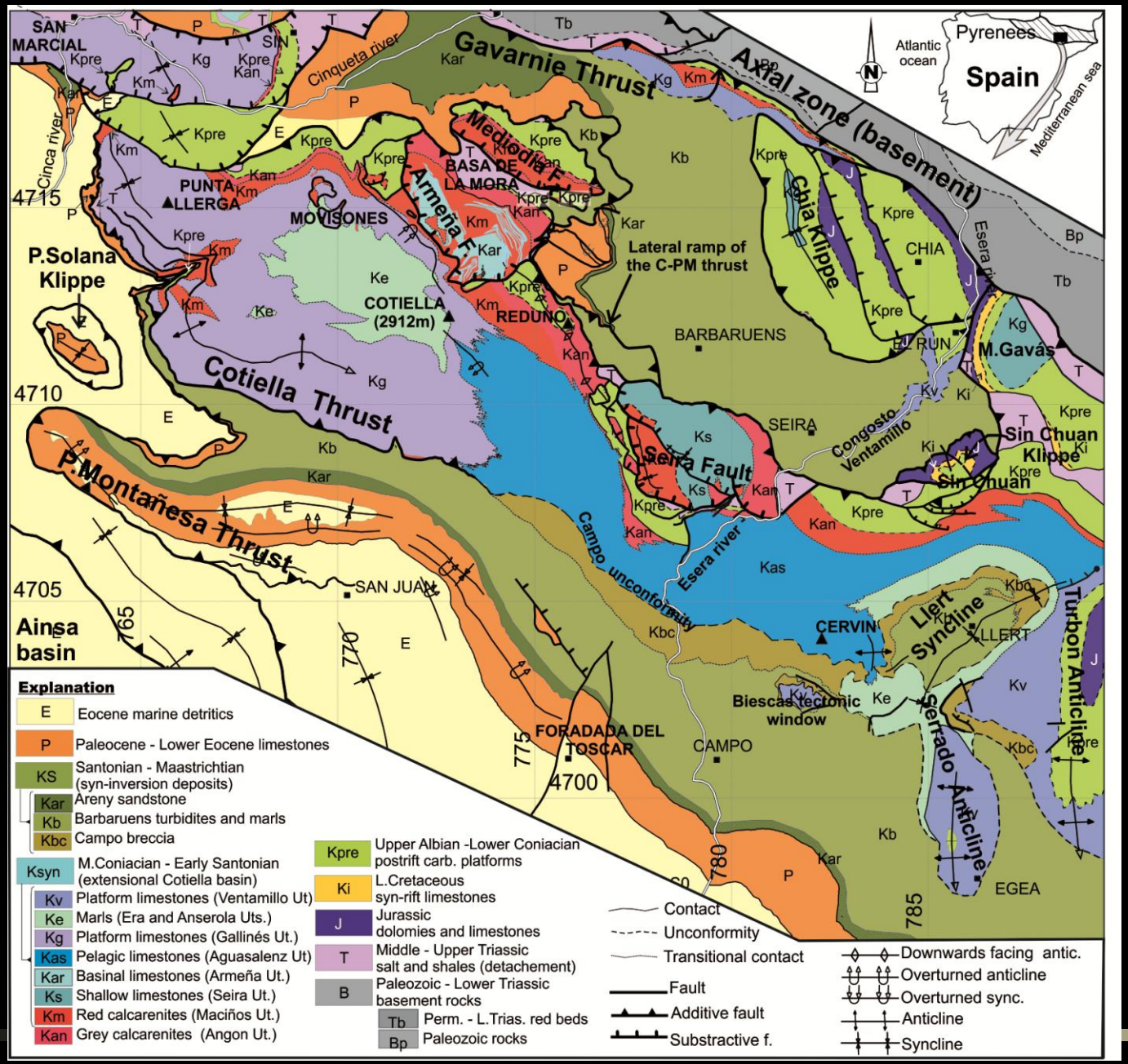

1:25.000 geological map of the Cotiella thrust sheet

2. The Cotiella thrust sheet: structural setting

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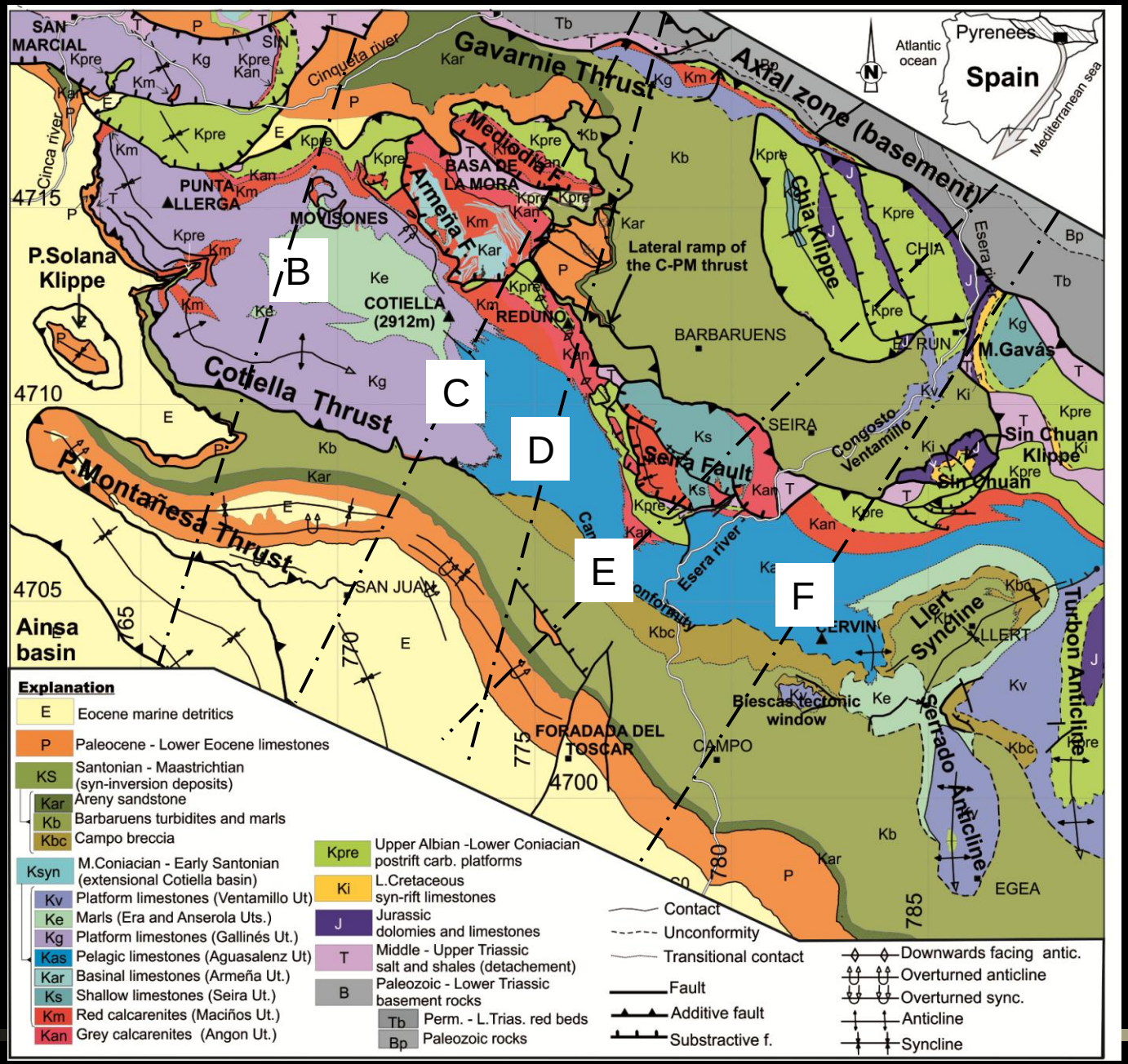
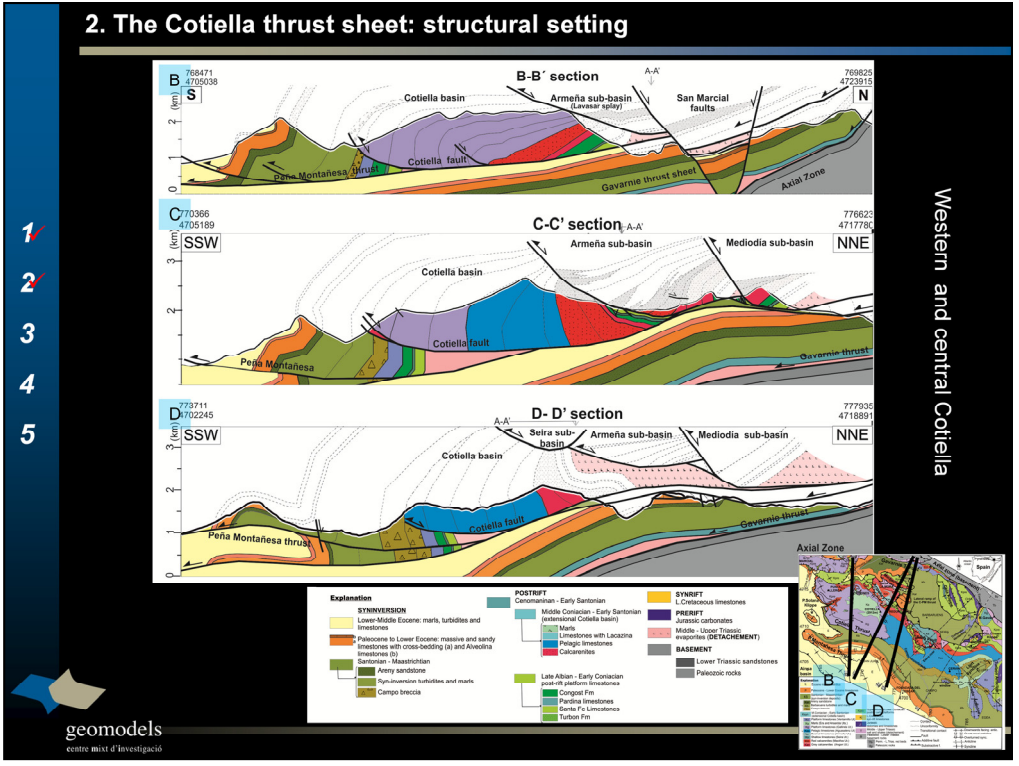


1:25.000 geological map of the Cotiella thrust sheet



Presenter's notes: The Cotiella s.s. thrust sheet consists of a 4-km succession of upper Albian to lower Santonian post-rift units (Souquet, 1967, Séguret, 1972; Garrido and Ríos, 1972) which unconformably overlie the pre-rift Triassic evaporites.

2. The Cotiella thrust sheet: structural setting

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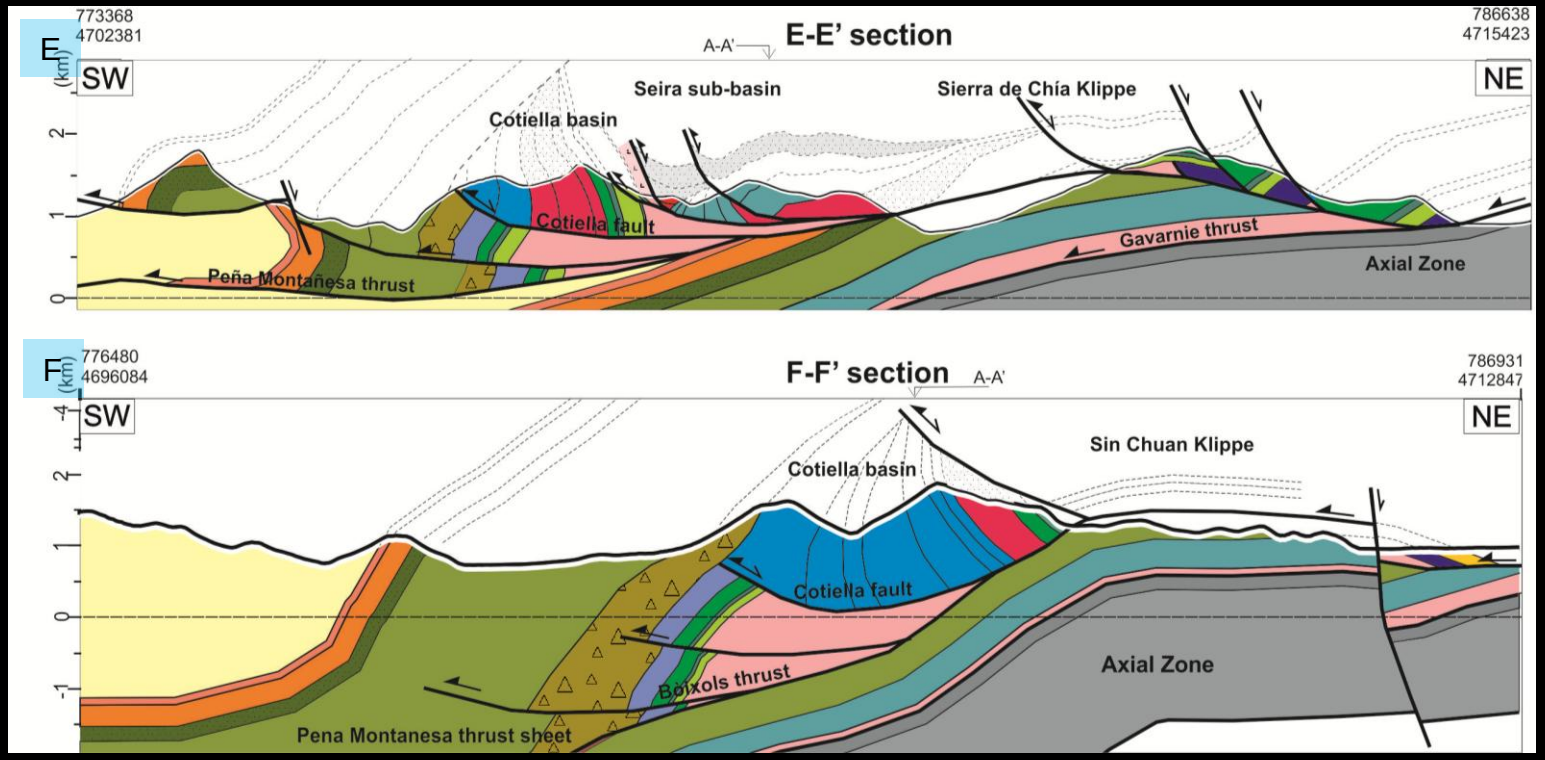
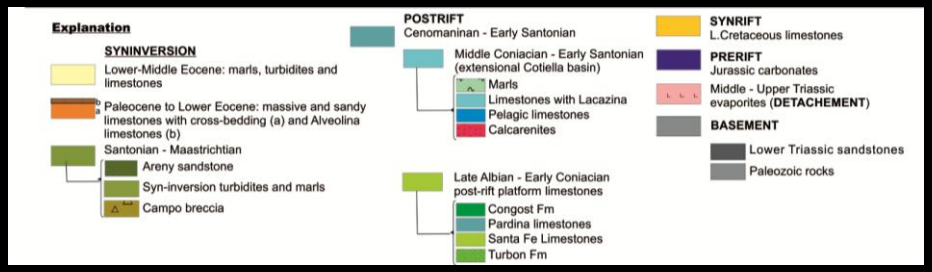
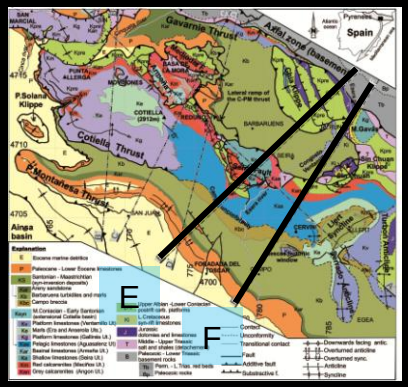
Eastern Cotiella







3. The Cotiella extensional system

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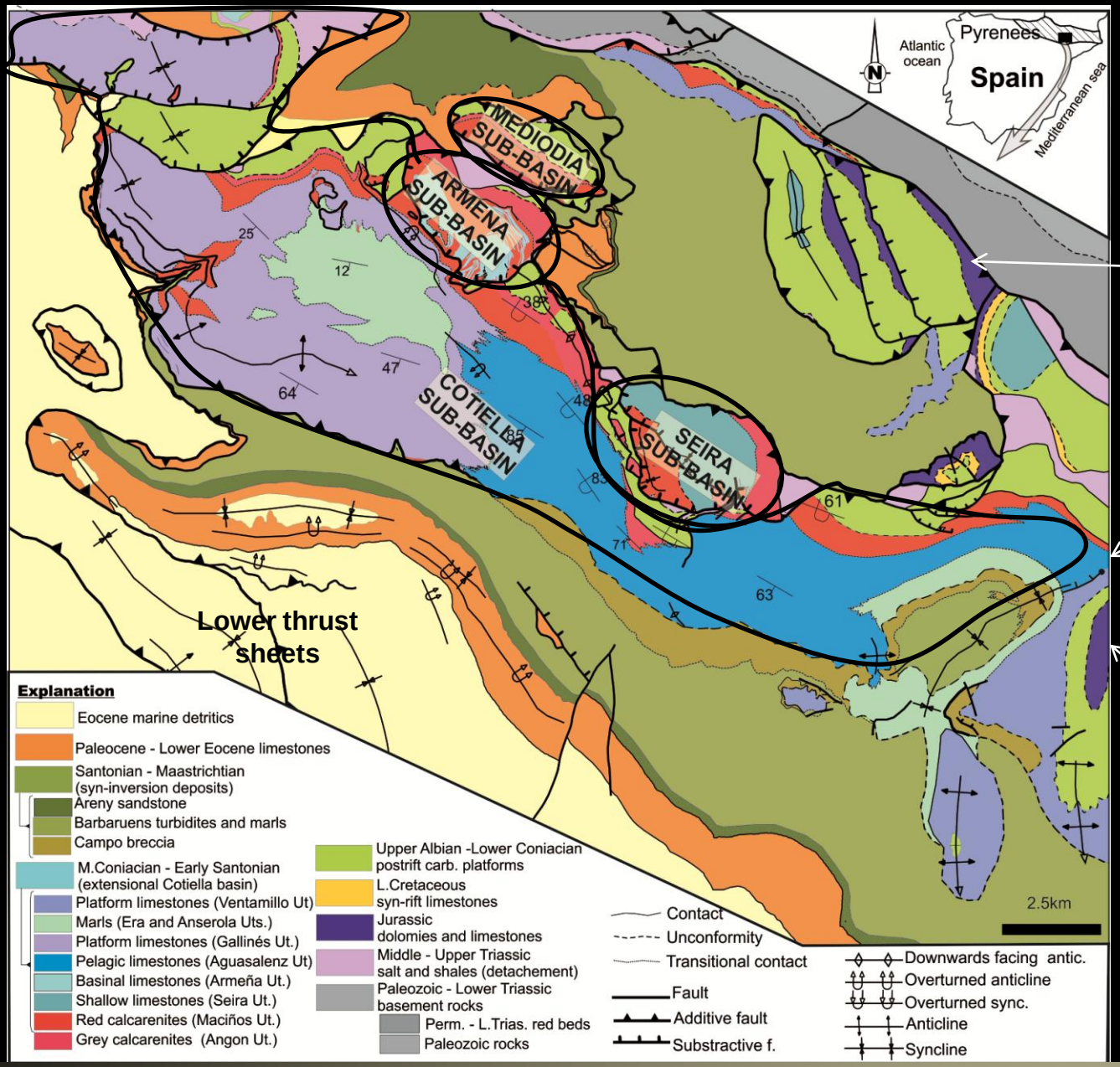

3. The Cotiella extensional system

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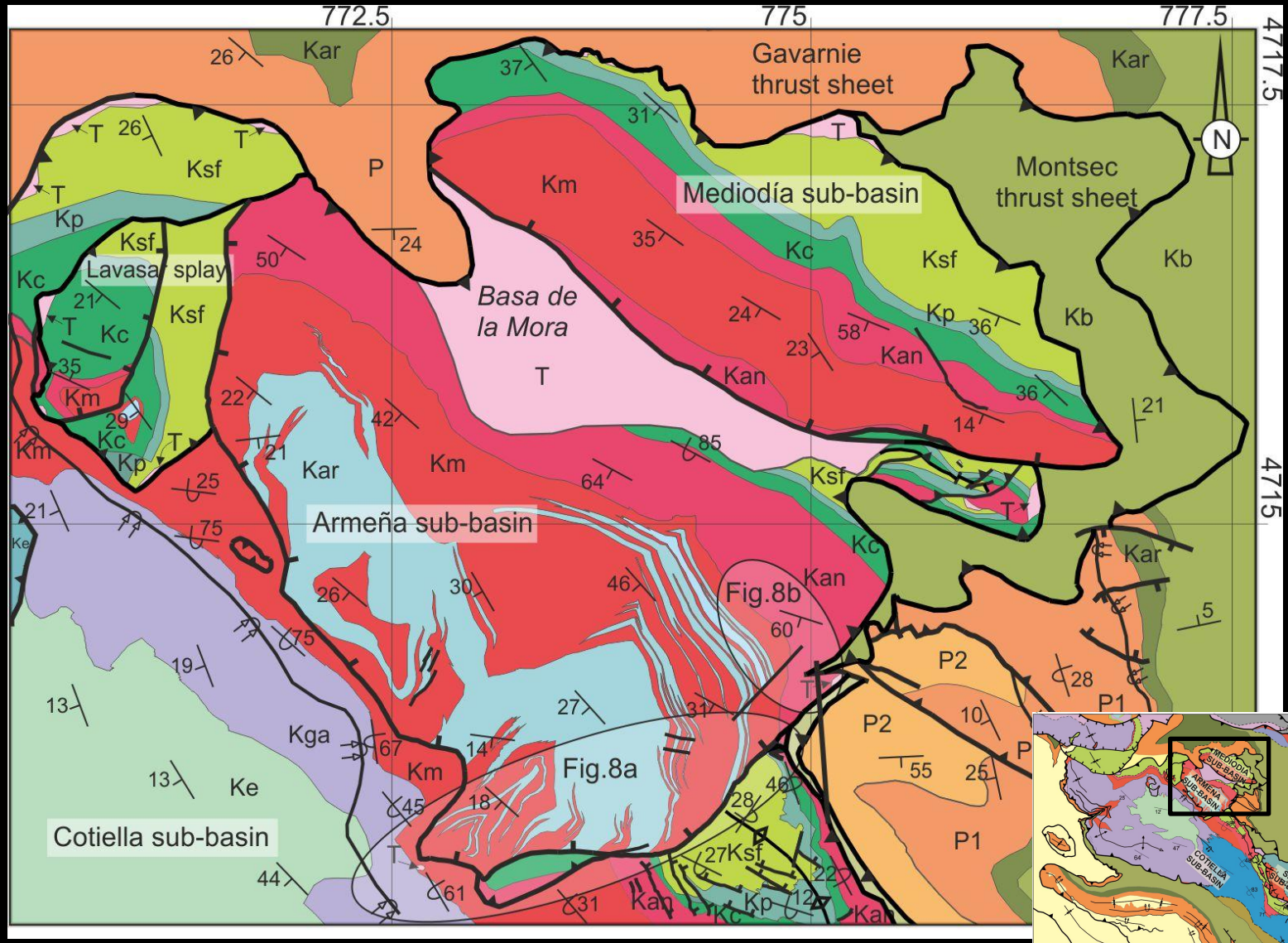
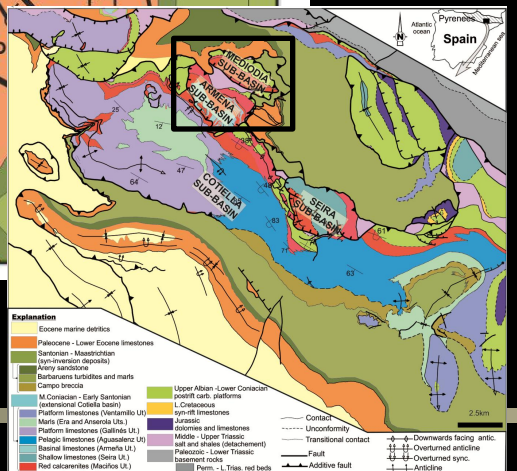
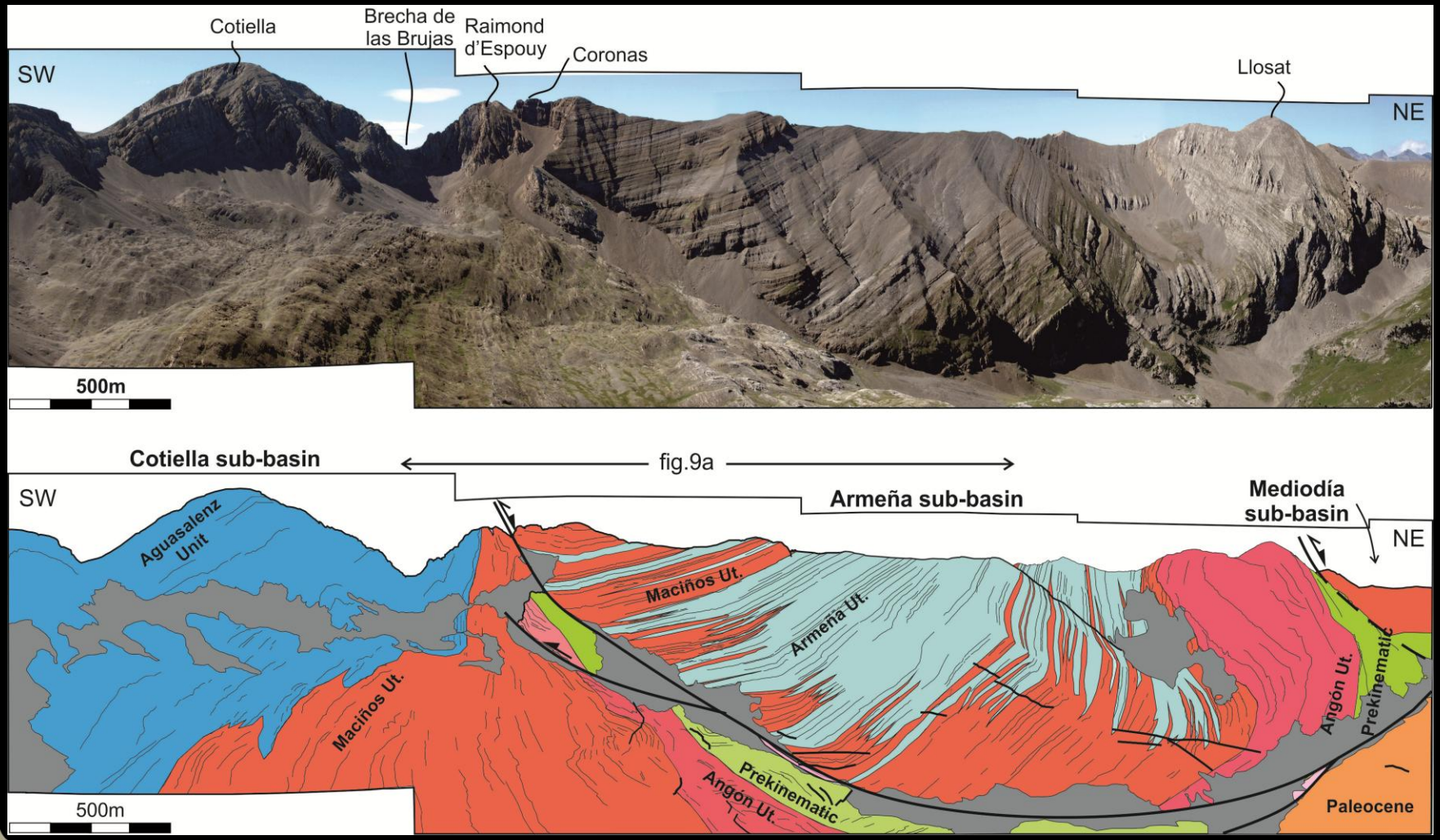




4. The Cotiella extensional system

Facies distribution in the Armena Ridge



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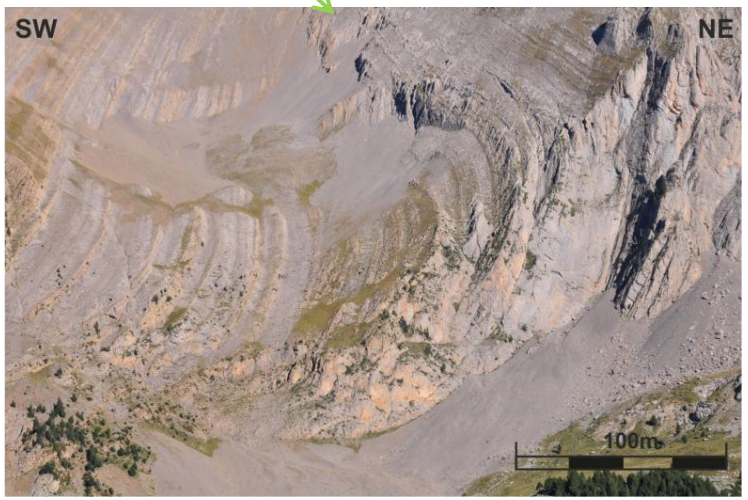
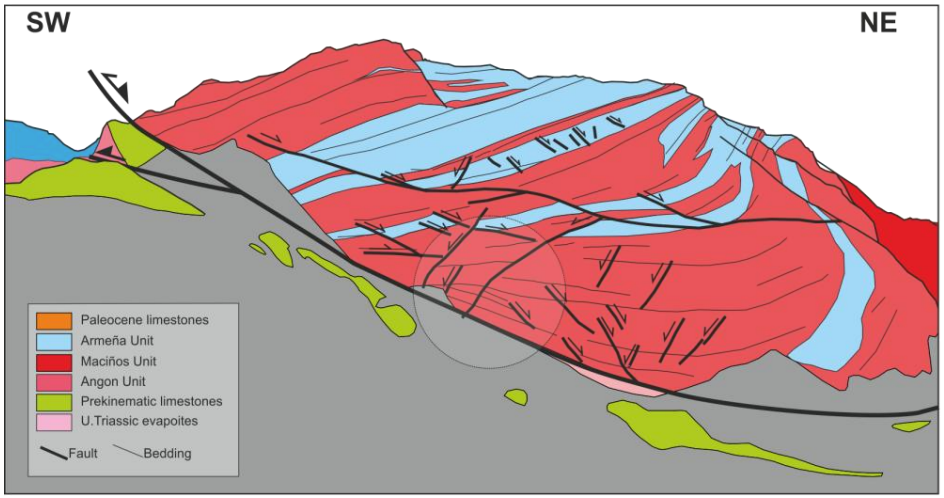
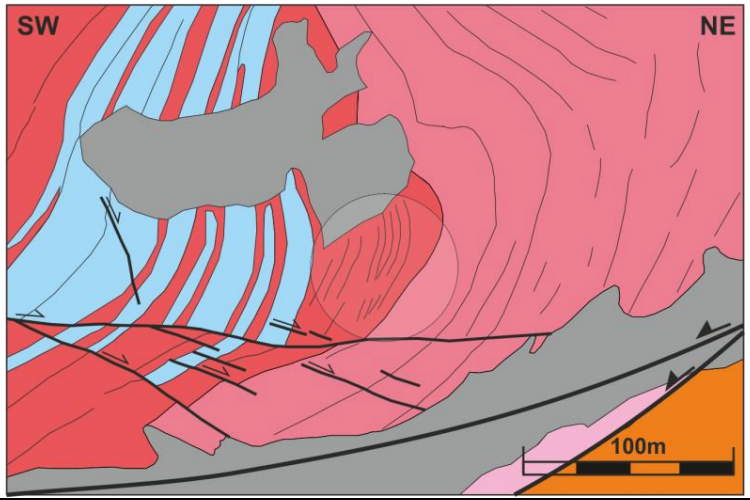
4. The Cotiella extensional system







3. The Cotiella extensional system

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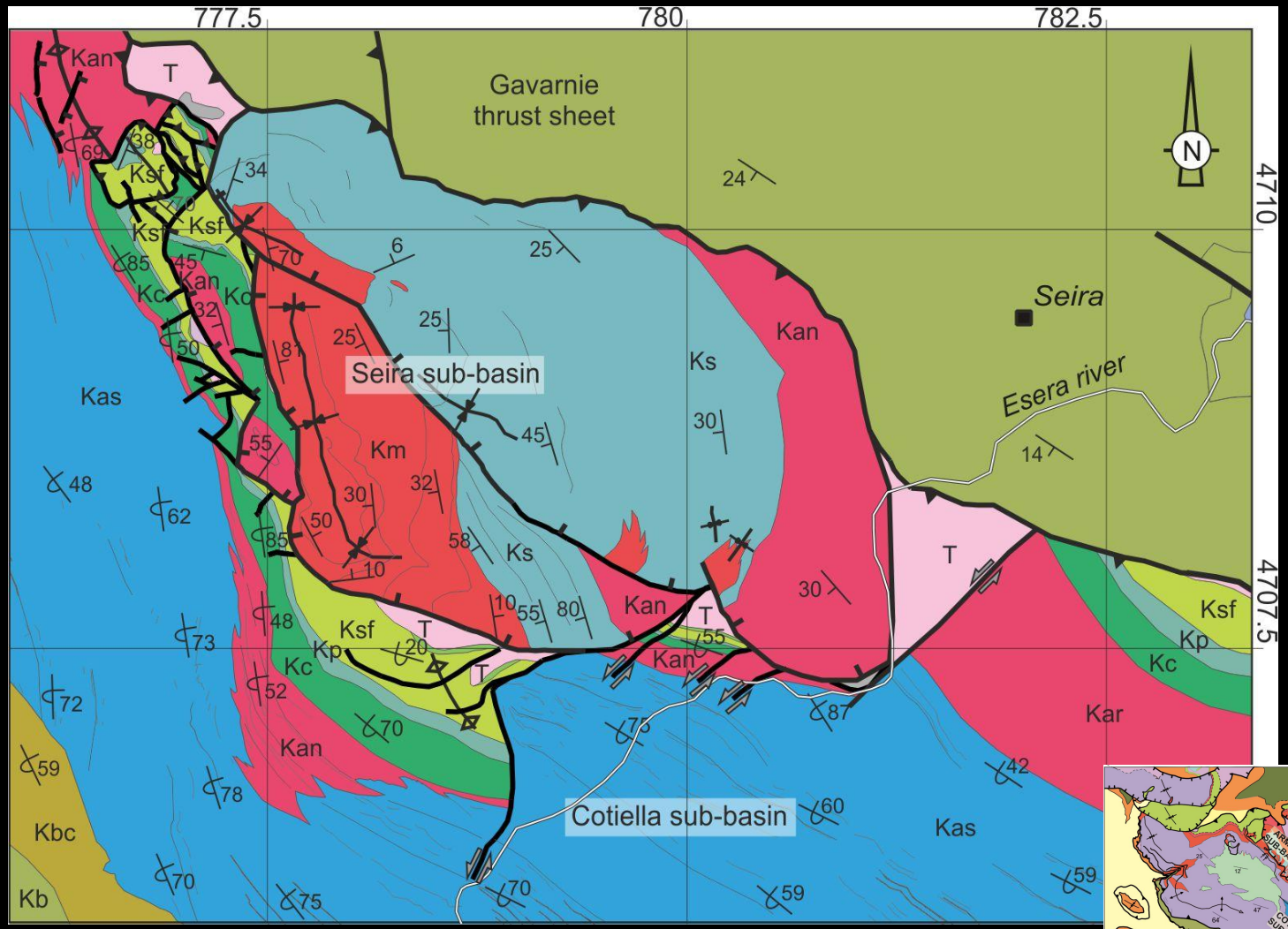
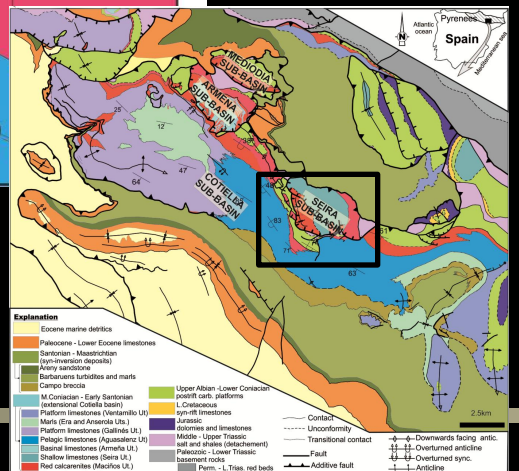
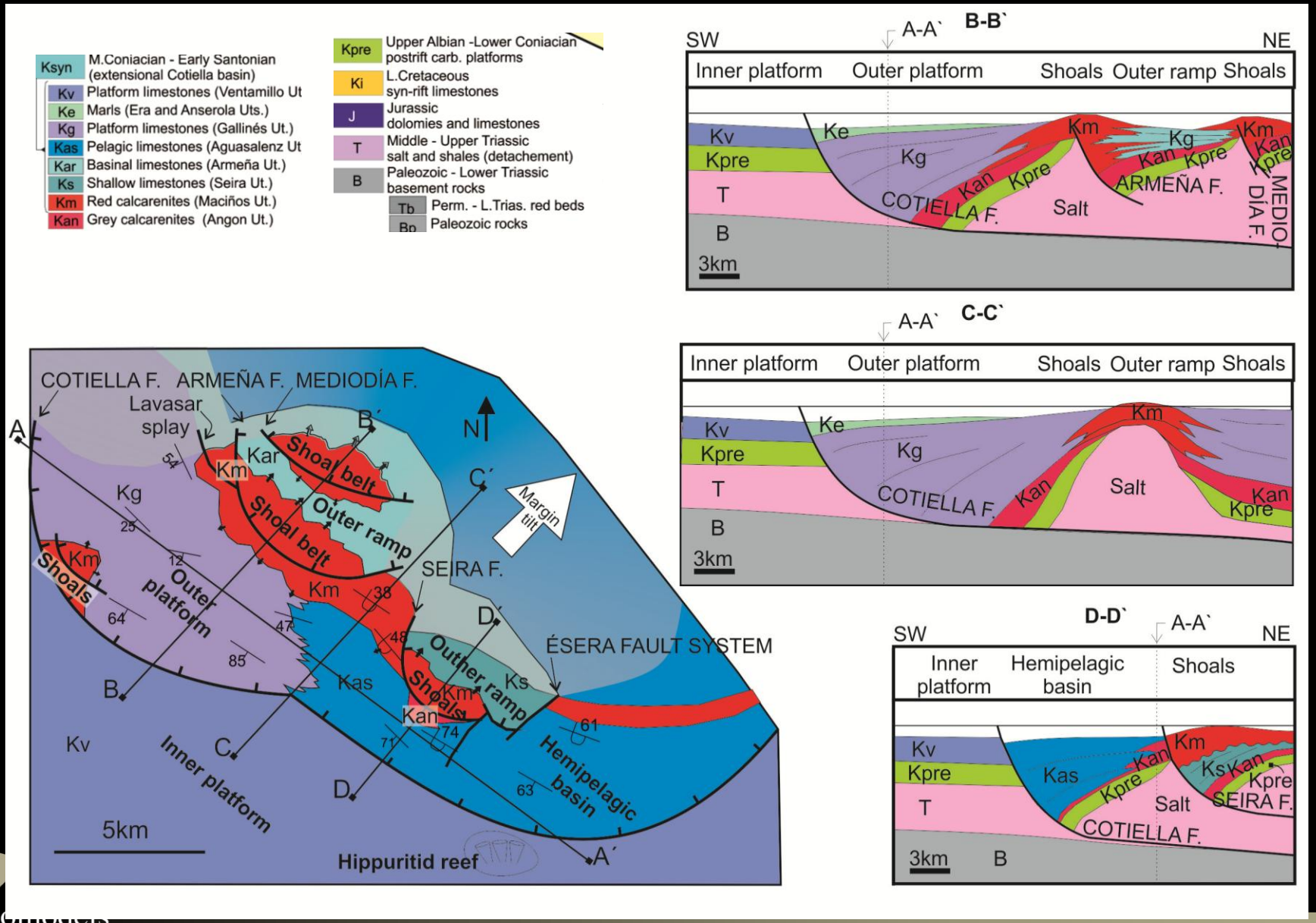




4. Role of salt tectonics

Sketched restored cross-sections showing the facies distribution in the Cotiella basin



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4. Role of salt tectonics

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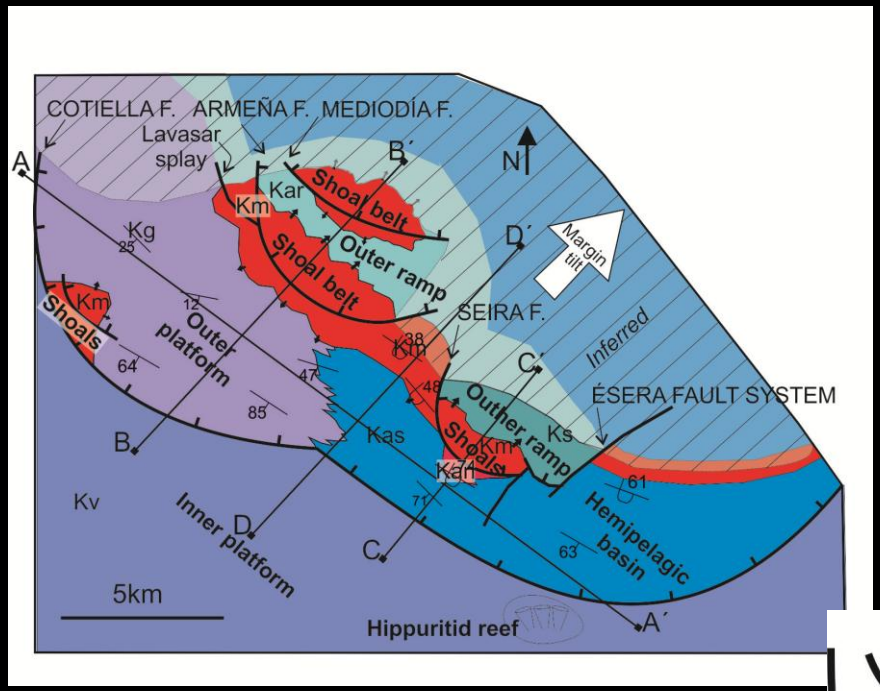
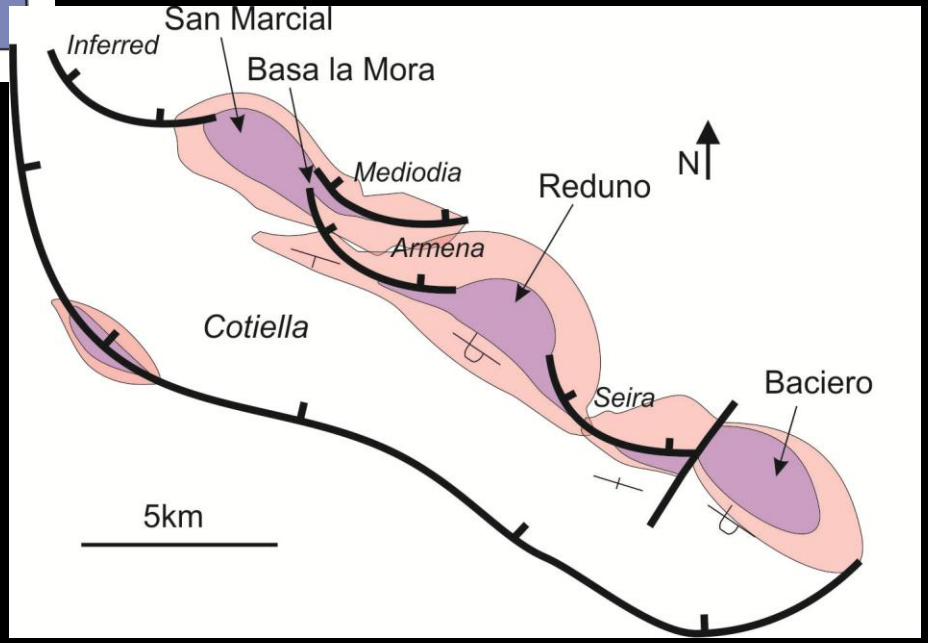
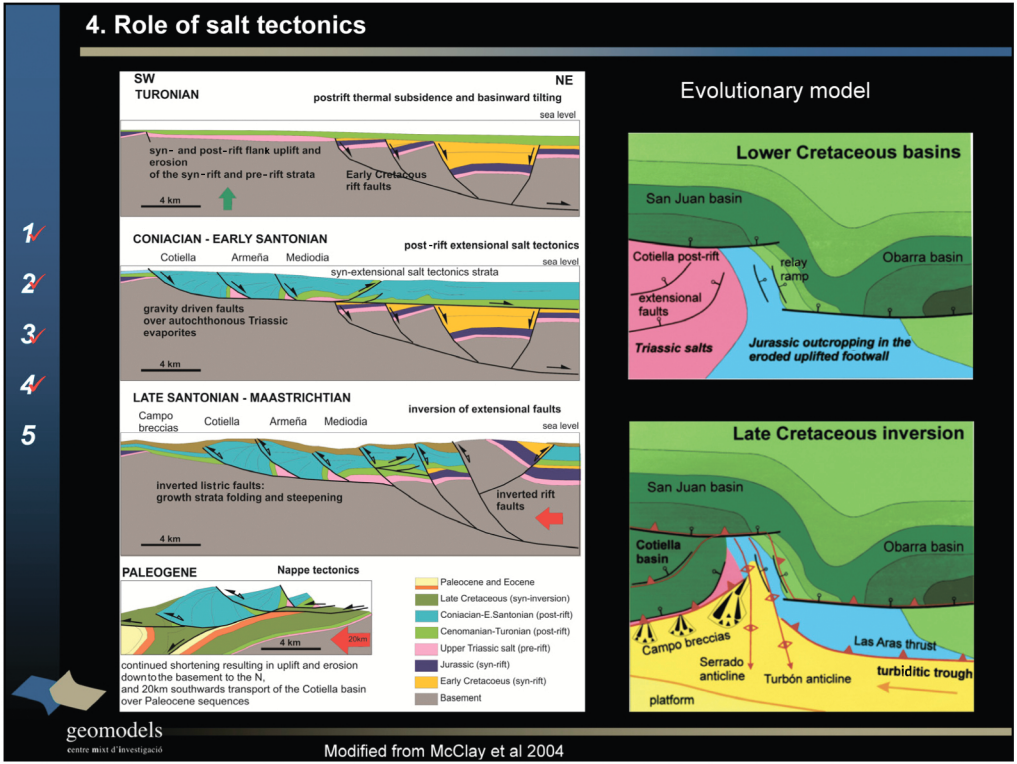


Sketched restored maps showing the facies distribution and the location of the main diapirs in the Cotiella basin

Ksyn	M.Coniacian - Early Santonian (extensional Cotiella basin)
Kv	Platform limestones (Ventamillo Ut
Ke	Marls (Era and Anserola Uts.)
Kg	Platform limestones (Gallinés Ut.)
Kas	Pelagic limestones (Aguasalenz Ut
Kar	Basinal limestones (Armeña Ut.)
Ks	Shallow limestones (Seira Ut.)
Km	Red calcarenites (Maciños Ut.)
Kan	Grey calcarenites (Angon Ut.)

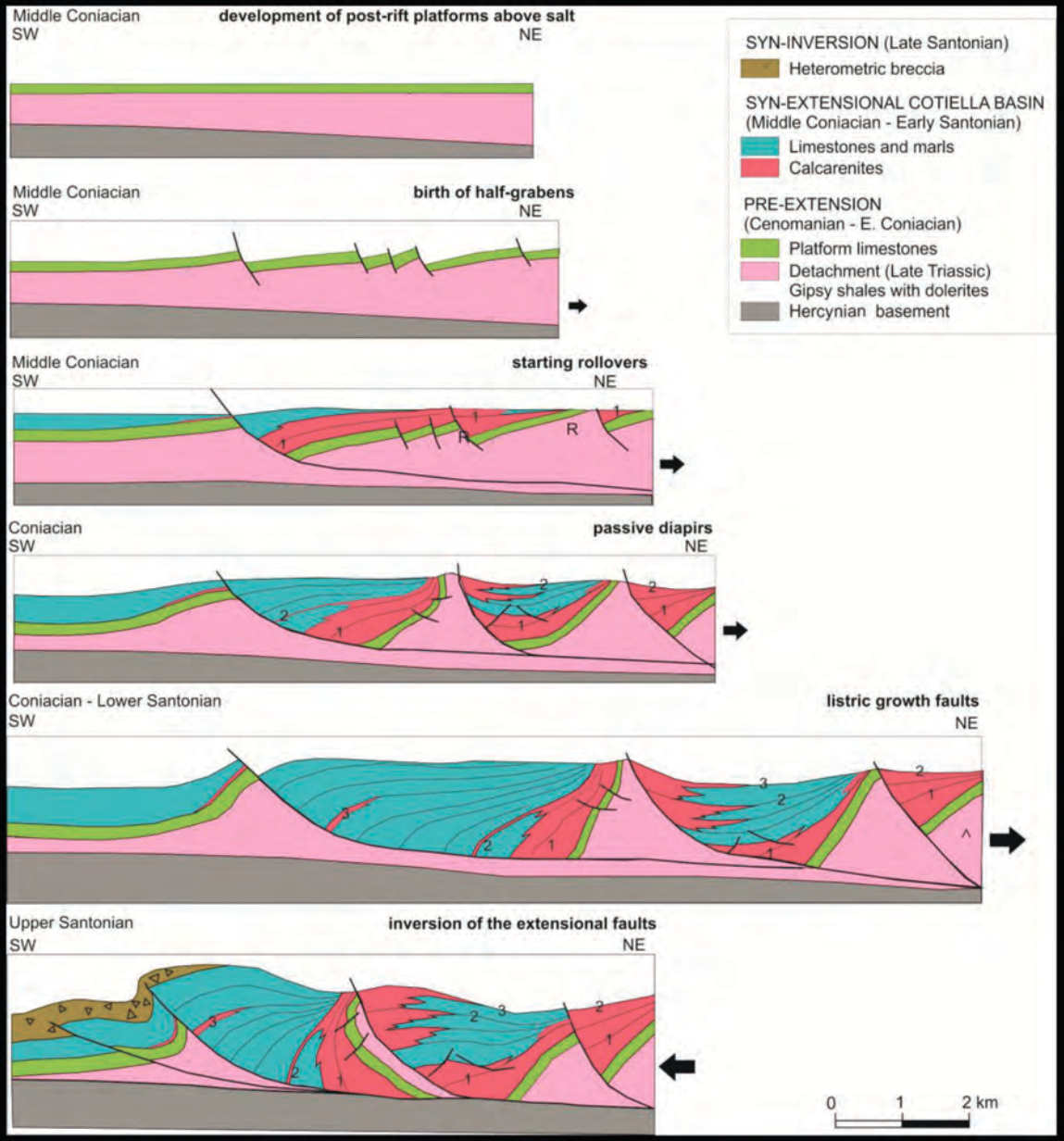
Kpre	Upper Albian -Lower Coniacian postrift carb. platforms
Ki	L.Cretaceous syn-rift limestones
J	Jurassic dolomies and limestones
T	Middle - Upper Triassic salt and shales (detachement)
B	Paleozoic - Lower Triassic basement rocks
Tb	Perm. - L.Trias. red beds
Bp	Paleozoic rocks





Presenter's notes: This Late Cretaceous extensional fault system has been interpreted to have been formed by gravity-driven extension over a ductile layer in a manner similar to that proposed for the South Atlantic passive margins (McClay et al., 2004). The extensional faults were reactivated during Pyrenean shortening as large hangingwall antiforms, some with an overturned rollover core. Nevertheless, in all cases the original extensional geometries of the listric growth faults can be recognized. Moreover, the sedimentological features of the carbonate and clastic sequences related to the extensional system are well preserved.

4. Role of salt tectonics



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5. Conclusions

1. The structural style of the study area is dominated by Late Cretaceous-Cenozoic thrust that transported and uplifted the Cotiella post-rift basin.
2. The Cotiella basin constitutes a middle Coniacian – early Santonian post-rift salt-floored basin developed in the Late Cretaceous Atlantic passive margin of the Pyrenees
3. It is dominated by thin-skinned gravity-driven extensional faults that detached into the Upper Triassic salts. They were coeval with passive diapirism and transfer faults.
4. In late Santonian times, the extensional faults were partially inverted and salt was extruded to form salt welds. Even so, extensional salt structures are well preserved.
5. The Cotiella basin constitutes a seismic-scale analogue for salt basins developed in other salt-involved passive margins such as the South Atlantic, the Gulf of Mexico and the North Sea.

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