Effect of rift inheritance and salt layers on mountain building - a numerical modelling study motivated by the southern Pyrenean foreland fold-and-thrust belt

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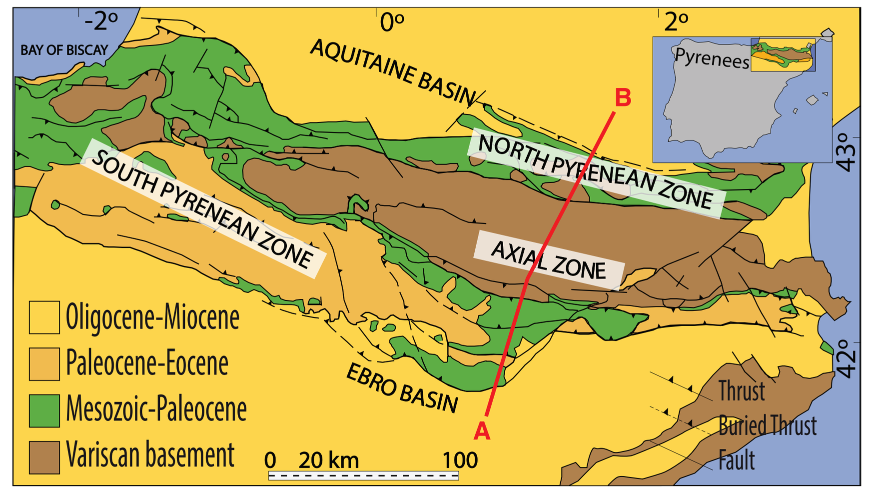
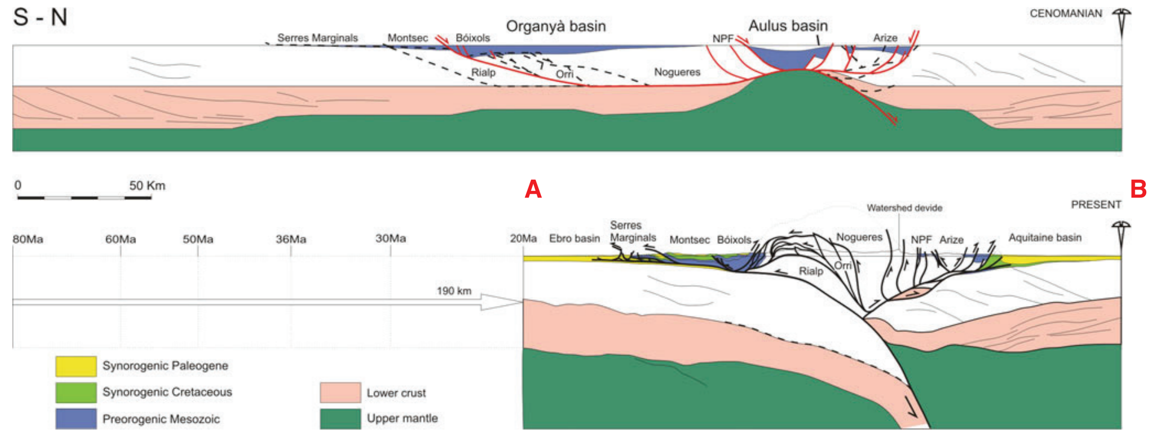
Motivation



Weak intra-crustal salt layers, syn-tectonic sedimentation and extensional inheritance strongly influence mountain belt evolution.

The Pyrenees represent a well-constrained example of an inversion orogen with salt-detached foreland fold-and-thrust belts.

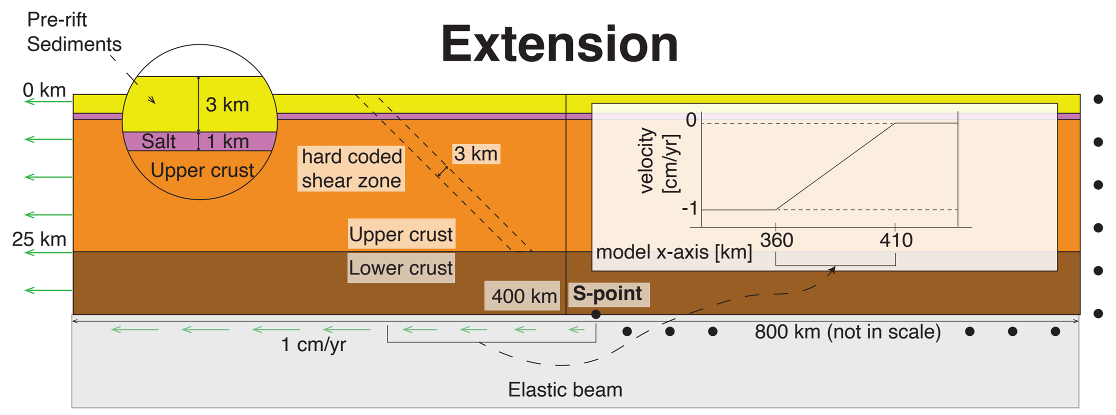
Two salt layers: (1) pre-contractional salt (Triassic)
(2) syn-contractional salt (Eocene)



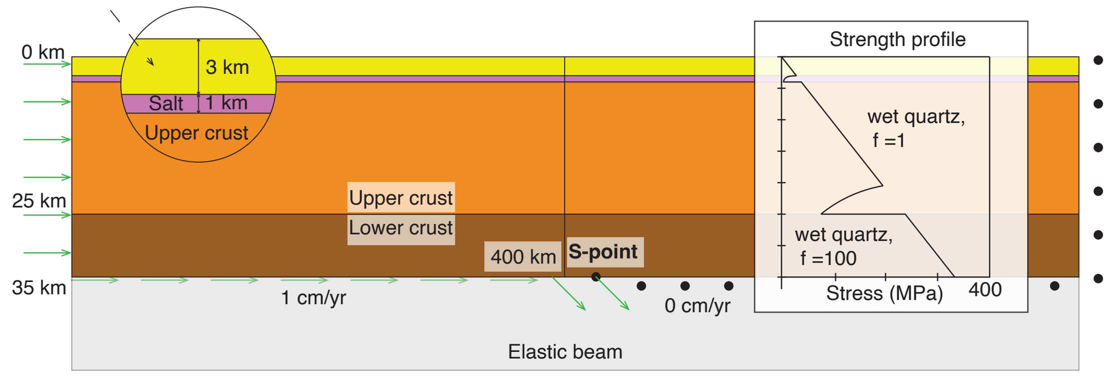
How do **salt** and **inherited structures** control deformation and orogenic geometry?

Method

Extension



Inversion and collision



2D thermo-mechanical numerical models using the finite-element code FANTOM 2D

Parameters tested:
- Extensional inheritance
- Presence and distribution of pre-contractional salt
- Syn-tectonic sedimentation

Simulation phases:
(1) 10 Ma of extension
(2) 10 Ma of contraction
(3) 10 Ma of contraction and subduction

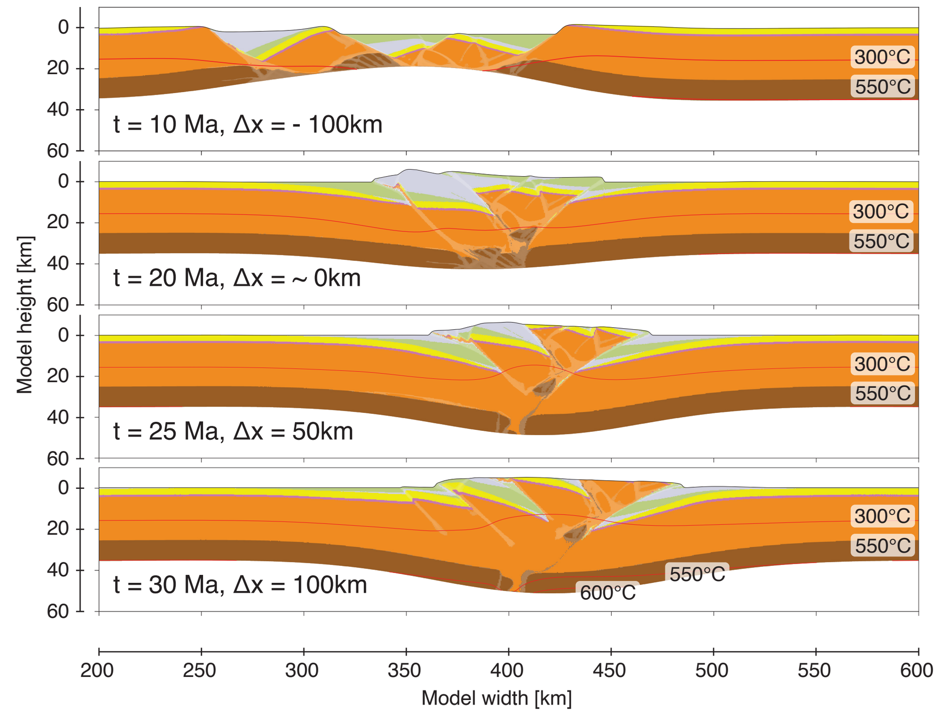
Erosion model

Both erosion and sedimentation are computed relative to the same topographic reference level. Erosion increases with elevation, while sedimentation fills upward toward the baselevel in a mass-conserving manner. We use an aggradation scheme with a constant sediment flux of 80m²/yr.

Formulation: $\frac{\partial h}{\partial t} = -k \cdot h$, where k is the erosion constant, h represents the surface elevation

Results

M1 - No Triassic salt, no syn-tect salt

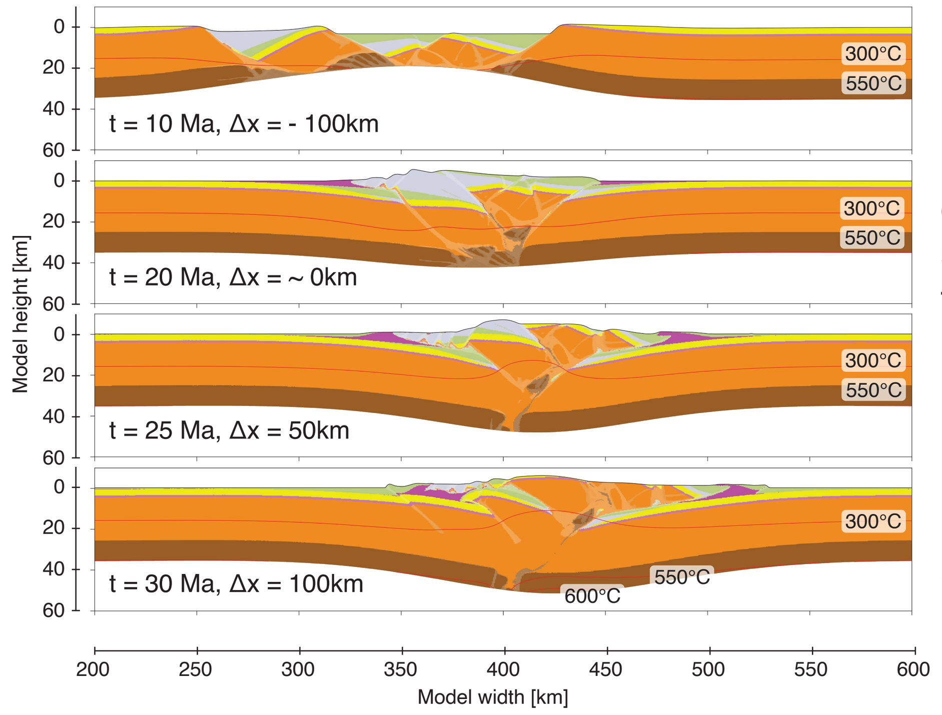


Extension: filled rift basin

End of inversion: restoration of the initial thickness; pop-up structure and faults inversion

Collision phase: sediment basins locking the thrust sheets; well defined basement thrust sheets

M2 - No Triassic salt, syn-tect salt at 18 Ma

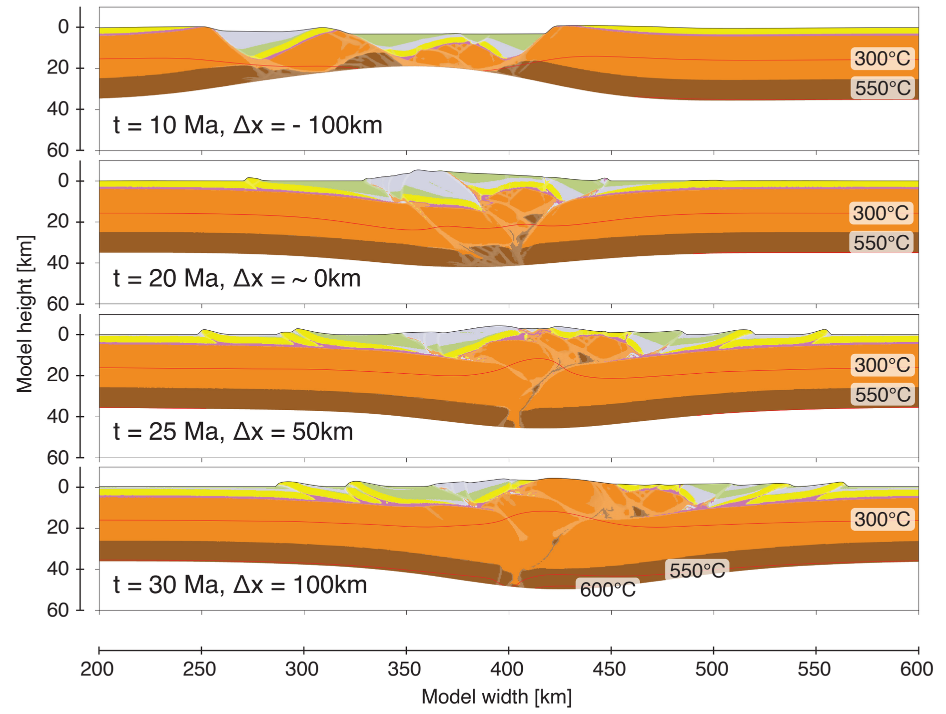


Extension: filled rift basin

End of inversion: restoration of the initial thickness; early syn-tectonic salt deposition in the foreland

Collision phase: salt tectonics with sediments on top of syn-tectonic salt; basement thrust sheets decoupled on syn-tectonic salt

M3 - Triassic salt, no syn-tect salt

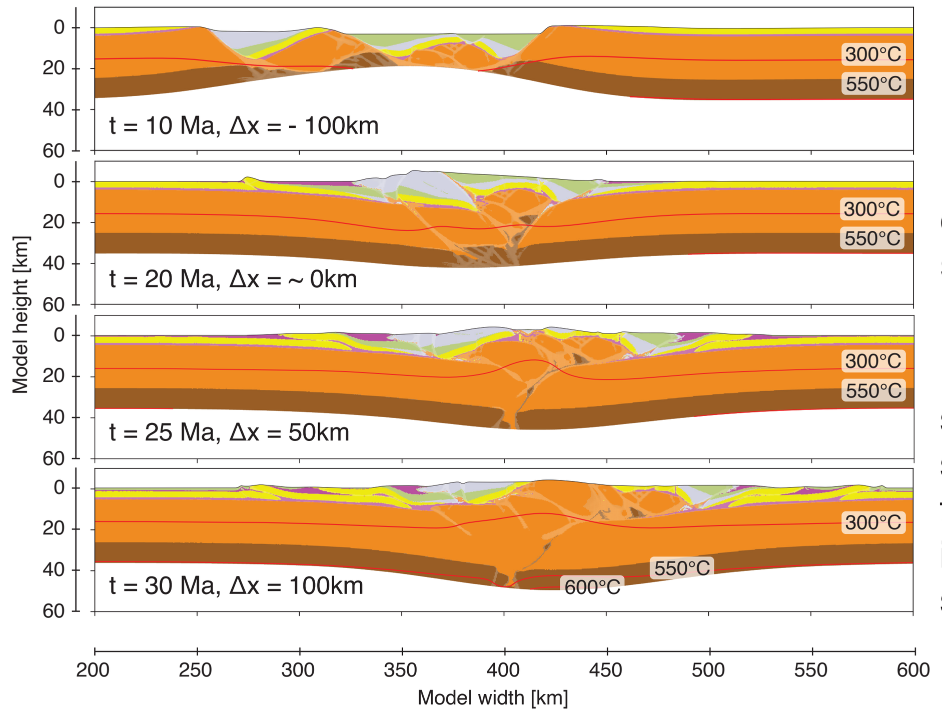


Extension: decoupling on salt horizon

End of inversion: inversion of extensional faults; migration of deformation into the thin-skinned FFTB

Collision phase: formation of antiformal stack; FFTB decoupled on salt

M4 - Triassic salt, syn-tect salt at 18 Ma

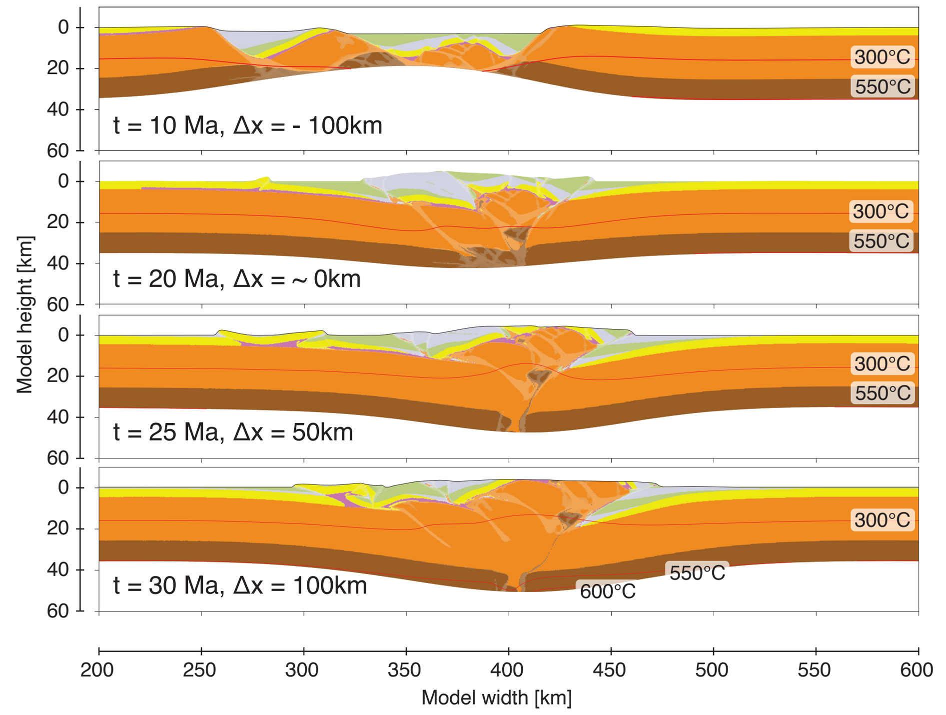


Extension: same as M3

End of inversion: restoration of initial thickness; syn-tectonic salt in a piggy-back basin

Collision phase: longer sediment cover thrust sheets; salt tectonics with sediment on top of the syntectonic salt; interaction between pre- and syn-tectonic salt

M5 - Asymmetric Triassic salt, no syn-tect salt

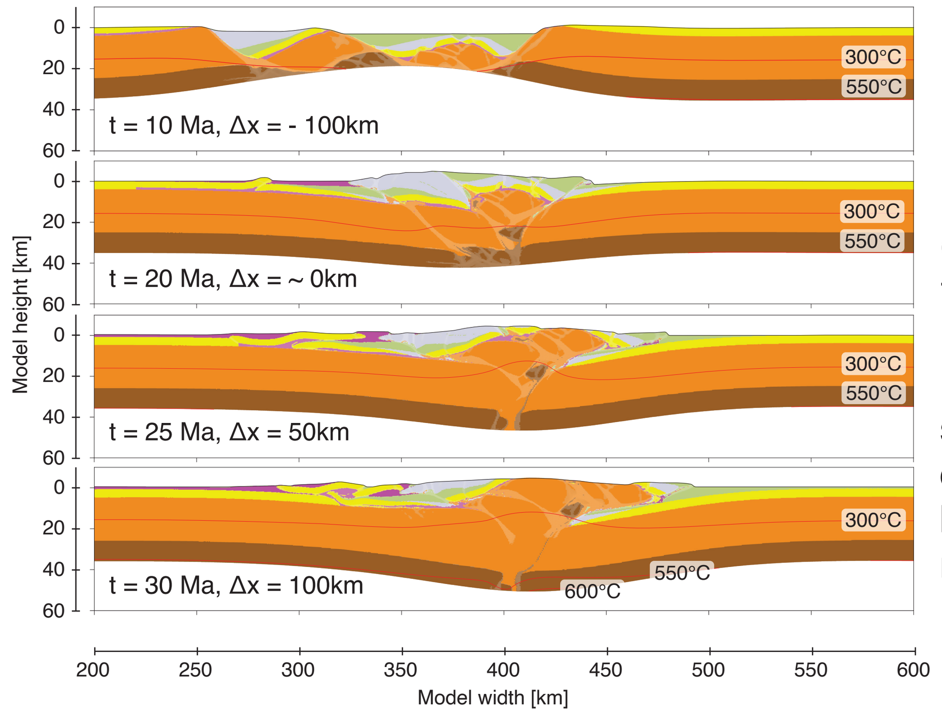


Extension: same as M3

End of inversion: similar to M3

Collision phase: Triassic salt controls thrust nucleation; fold-and-thrust belt forming only on the left side

M6 - Asymmetric Triassic salt, syn-tect at 18



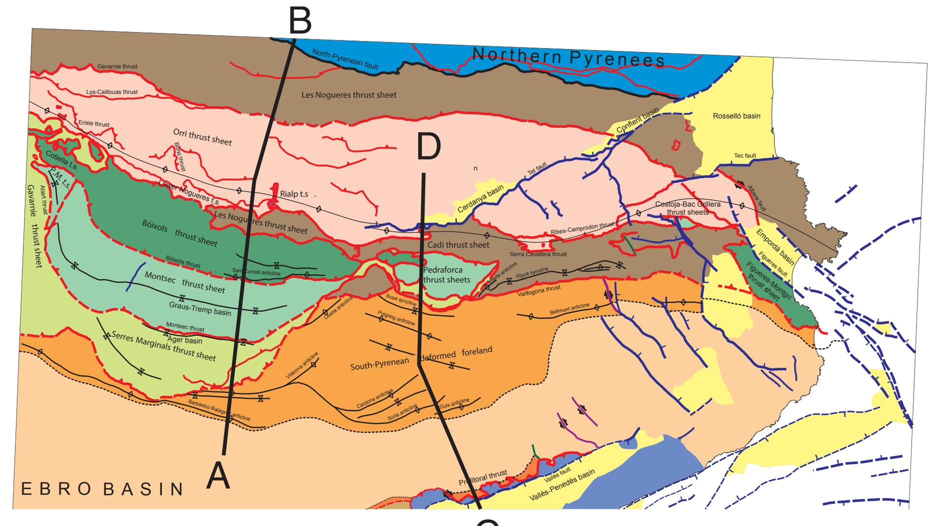
Extension: same as M3

End of inversion: faults inversion; different polarity of the (pro-wedge) foreland thrust

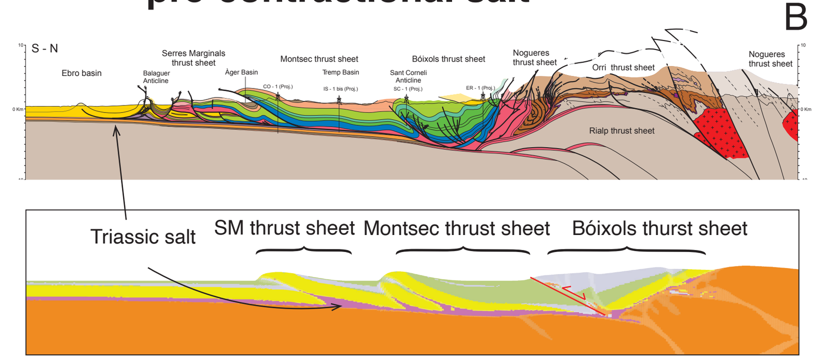
Collision phase: salt tectonics, with sediments on top of the syn-tectonic salt; basement thrust sheet nucleation delayed

Comparison to nature

Southern Pyrenees



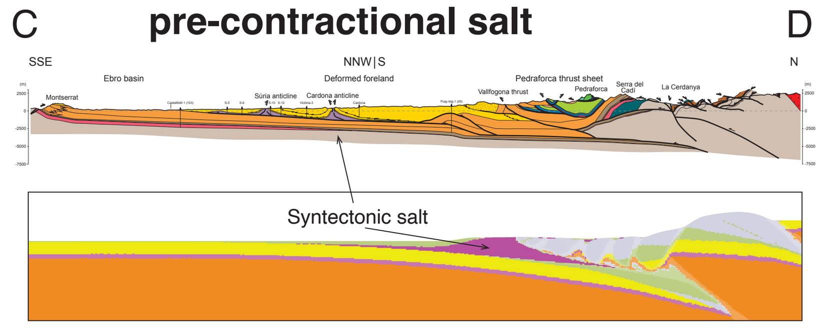
Presence of pre-contractional salt



First order comparison

Three foreland sediment-covered thrust sheets; inverted extensional basin consistent with natural observations

Absence of pre-contractional salt



No pre-contractional salt results in narrow coupled thrust sheets; late thin-skinned thrusts detaching on syn-tectonic salt

Conclusions

Extensional inheritance controls early stages of inversion and mountain building

Pre-existing salt layer promotes decoupling between thin- and thick-skinned deformation during extension and shortening, resulting in a FFTB and antiformal stack

Syn-tectonic salt interacts with sediment deposition and provides an addictional decoupling horizon

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