CRPG

UNIVERSITÉ DE LORRAINE

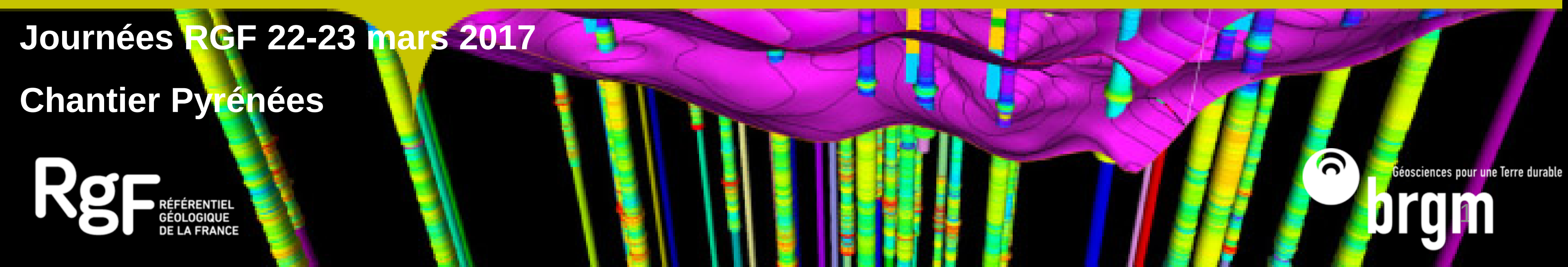
La Région Lorraine

RGF Chantier Pyrénées

Gravity anomalies, lateral variation of flexural rigidity, and flexure of a rifted continental margin: the Aquitaine Basin

Paul ANGRAND[1], Mary FORD[1], Anthony WATTS[2]

1: CRPG-CNRS Université de Lorraine, Nancy; 2: Oxford University, Oxford



Journées RGF 22-23 mars 2017

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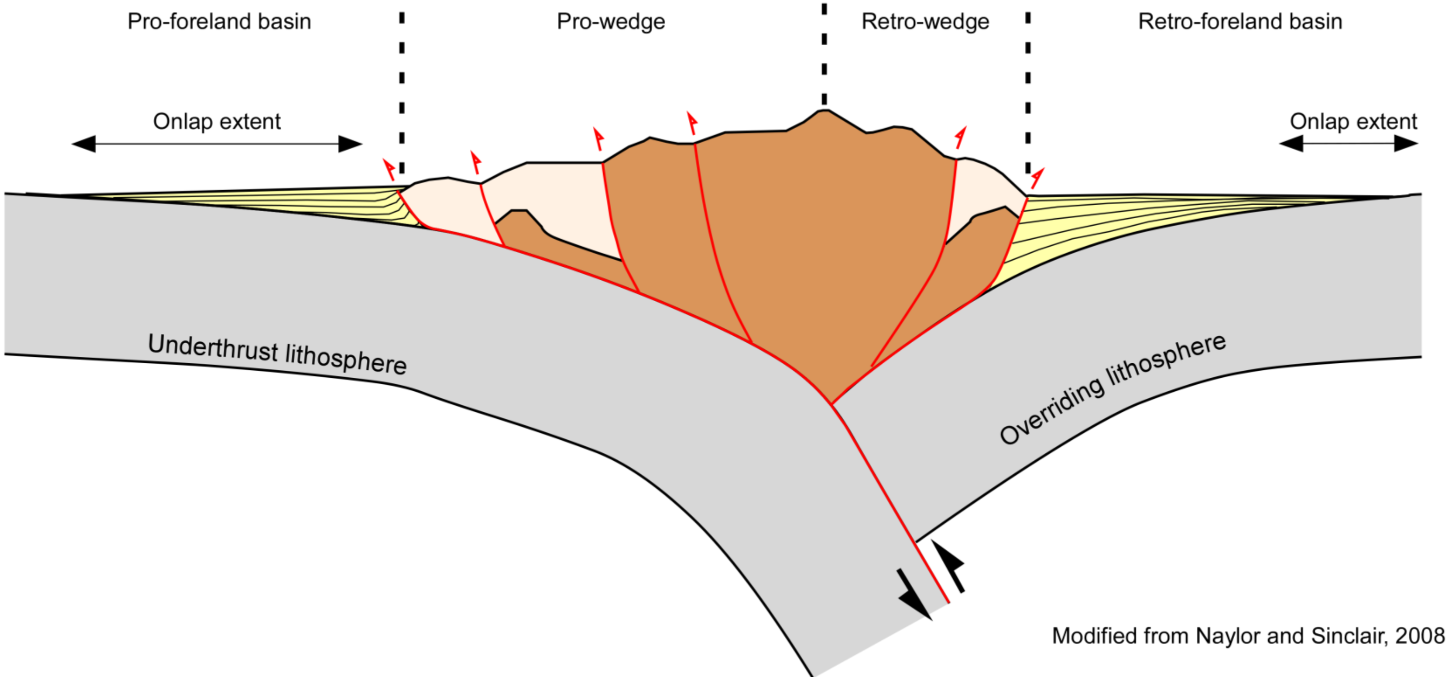
RGF RÉFÉRENTIEL GÉOLOGIQUE DE LA FRANCE

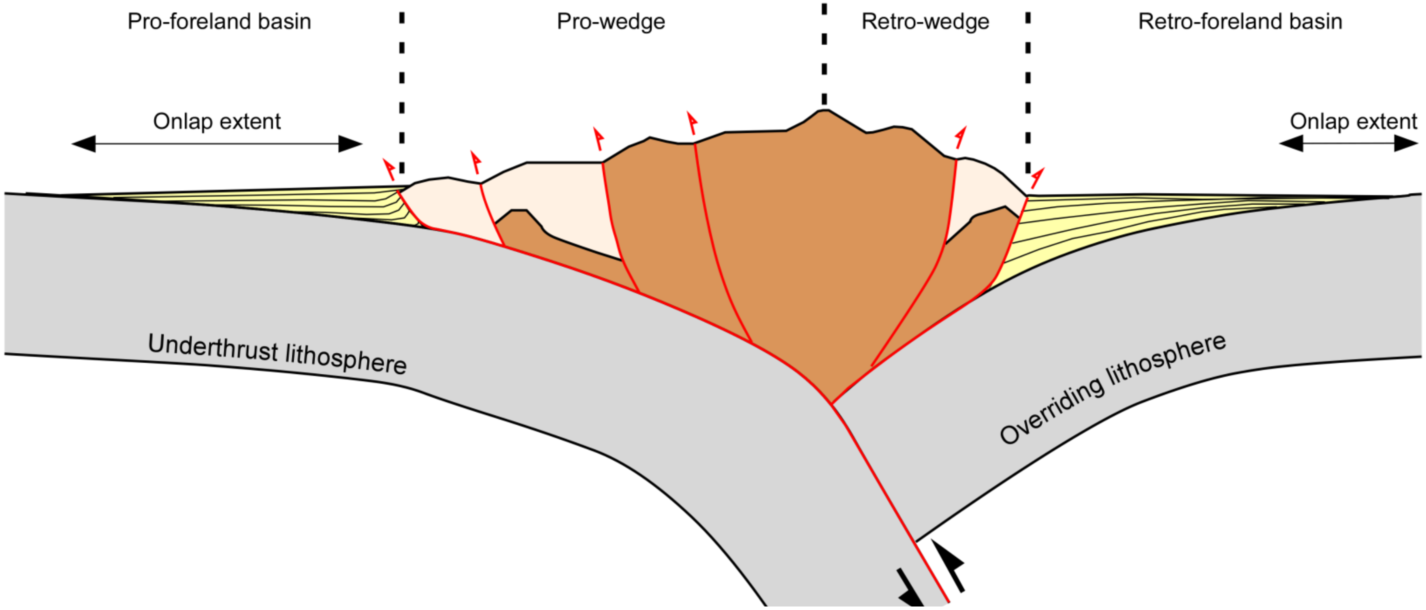
brgm Géosciences pour une Terre durable

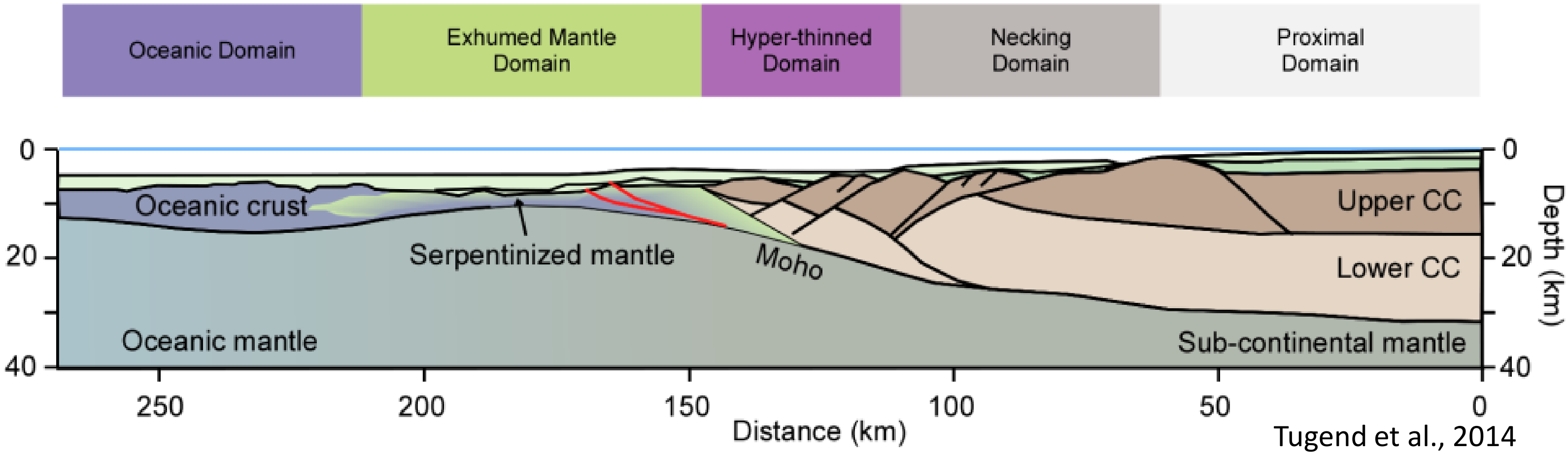


Flexural foreland basins that develop due to the load of the orogen

Geometry depends on the rigidity of the plate (Te)

Background | Foreland basins





Tugend et al., 2014

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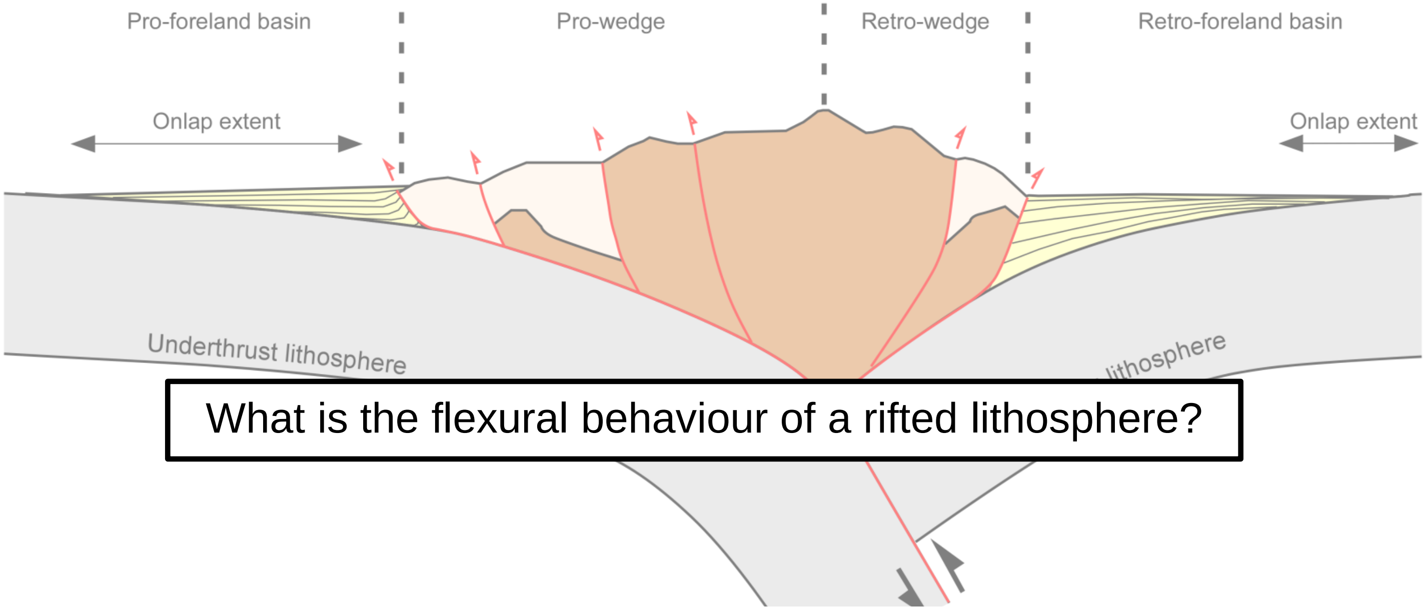
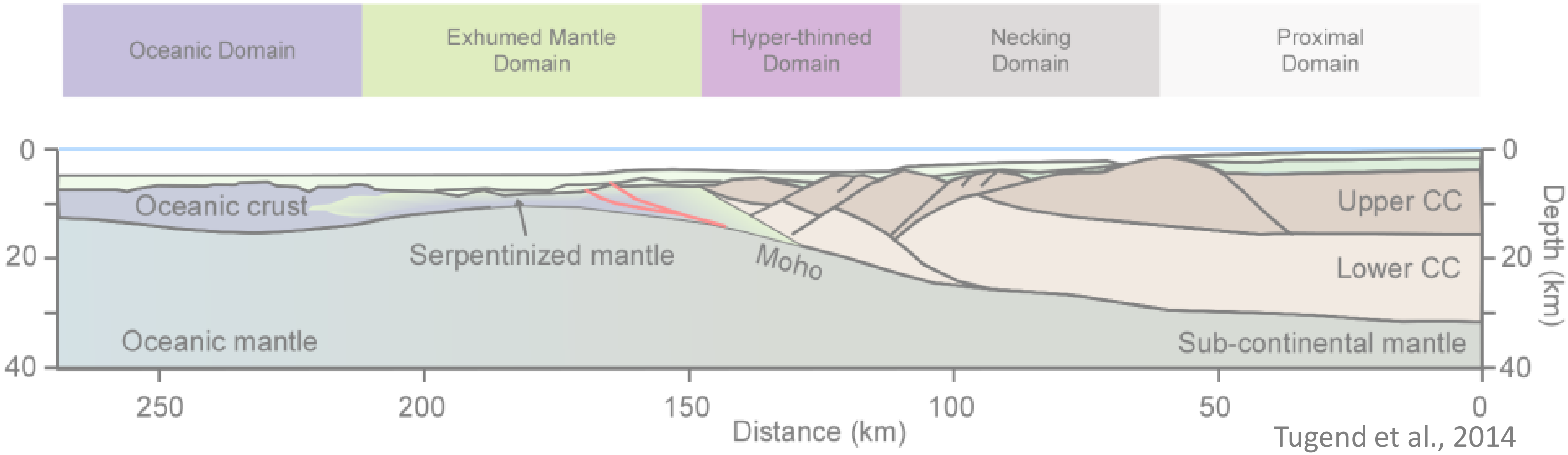


What is the flexural behaviour of a rifted lithosphere?



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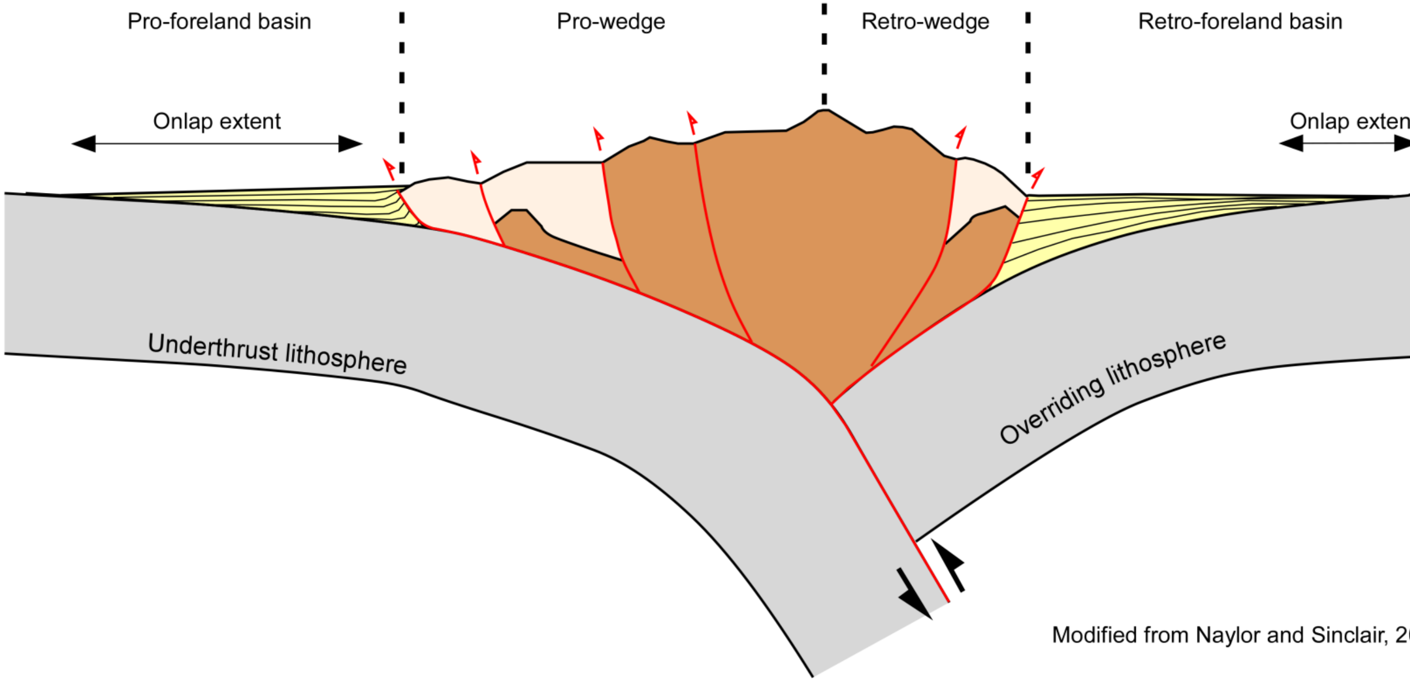
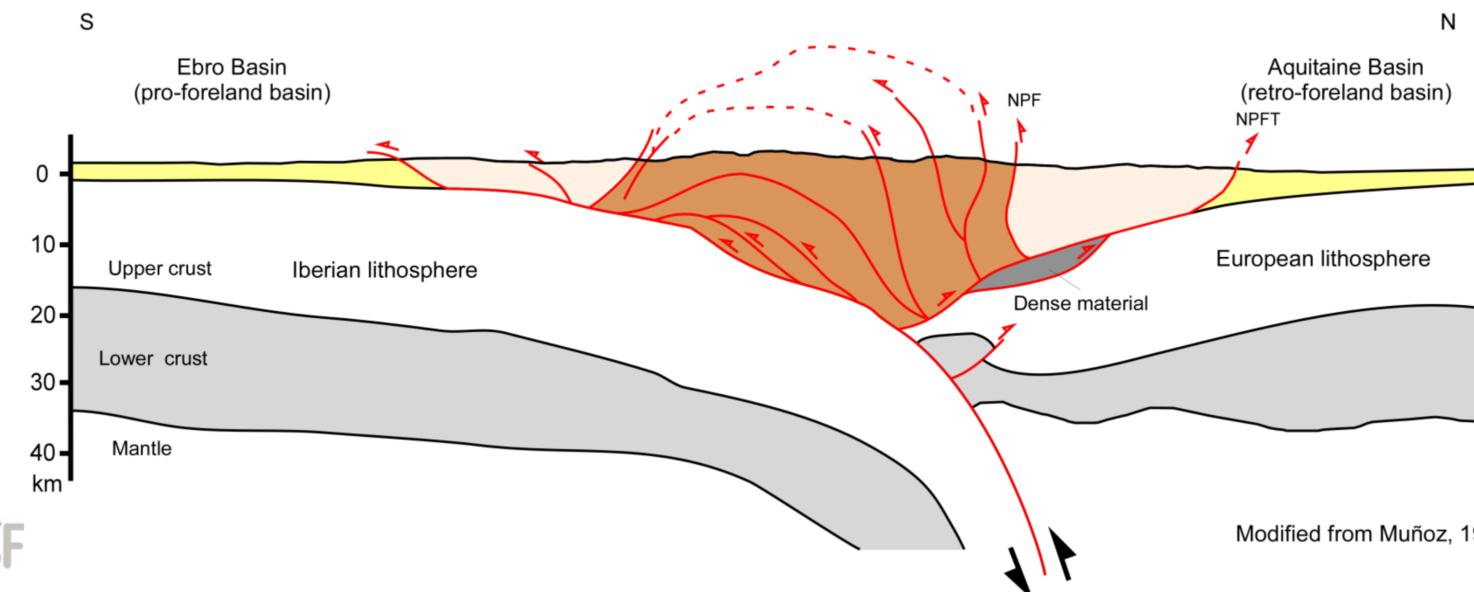


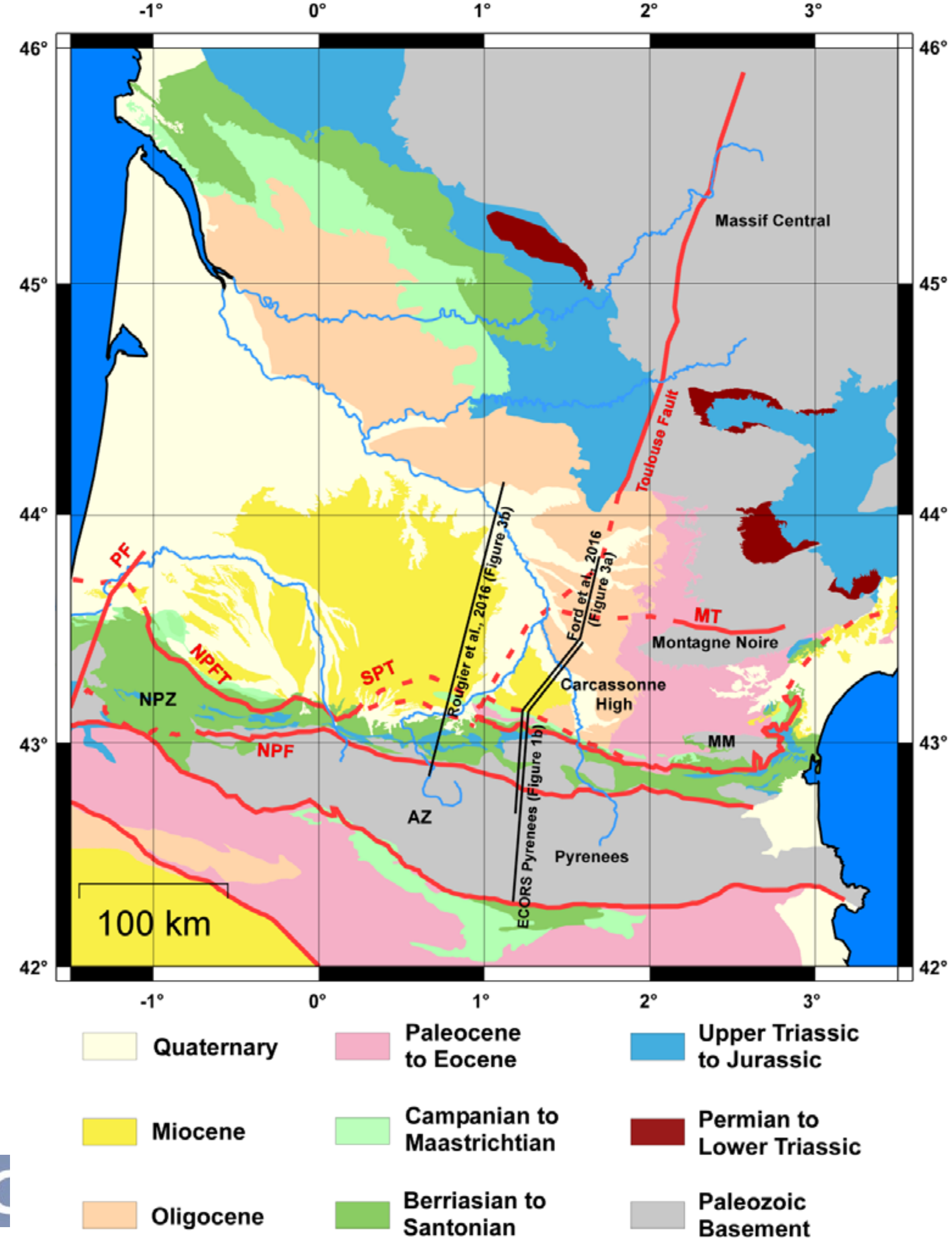
Modified from Naylor and Sinclair, 2008



Modified from Muñoz, 1992

Background | Geology of the Aquitaine Basin

- Pyrenean retro-foreland basin
- Syn-orogenic: Campanian to Miocene
- Asymmetric
- Structural inheritance (Apto-Cenomanian rifting: opening of the Bay of Biscay)
- Inherited faults
- Also post-orogenic events:
    - Opening of the Gulf of Lion
    - Pliocene uplift of the Massif Central



Angrand et al., in prep.

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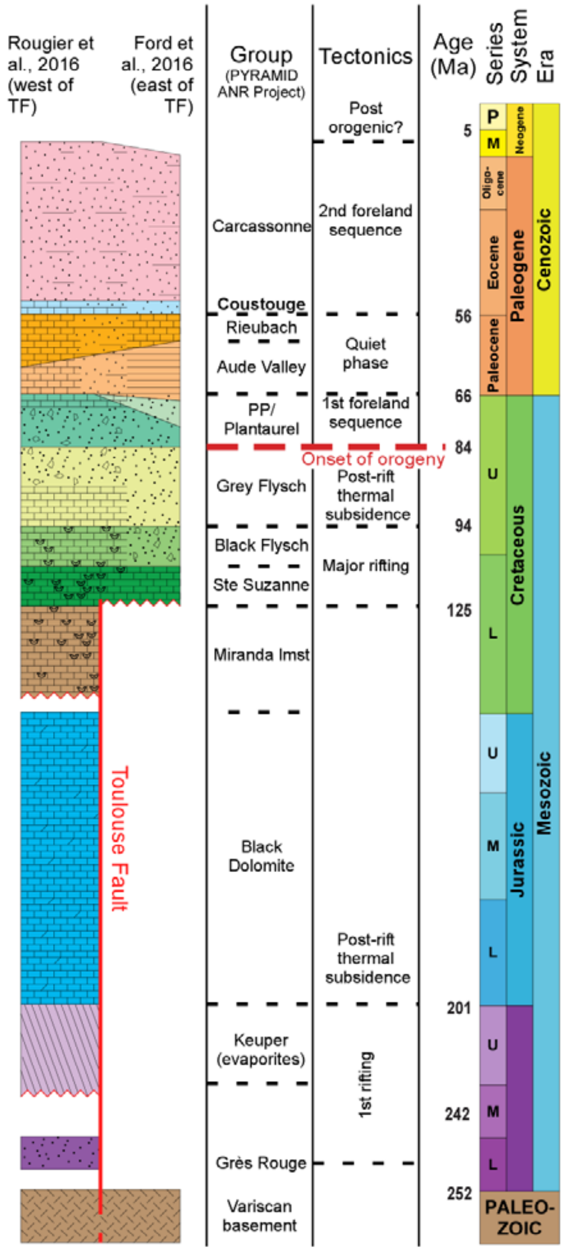

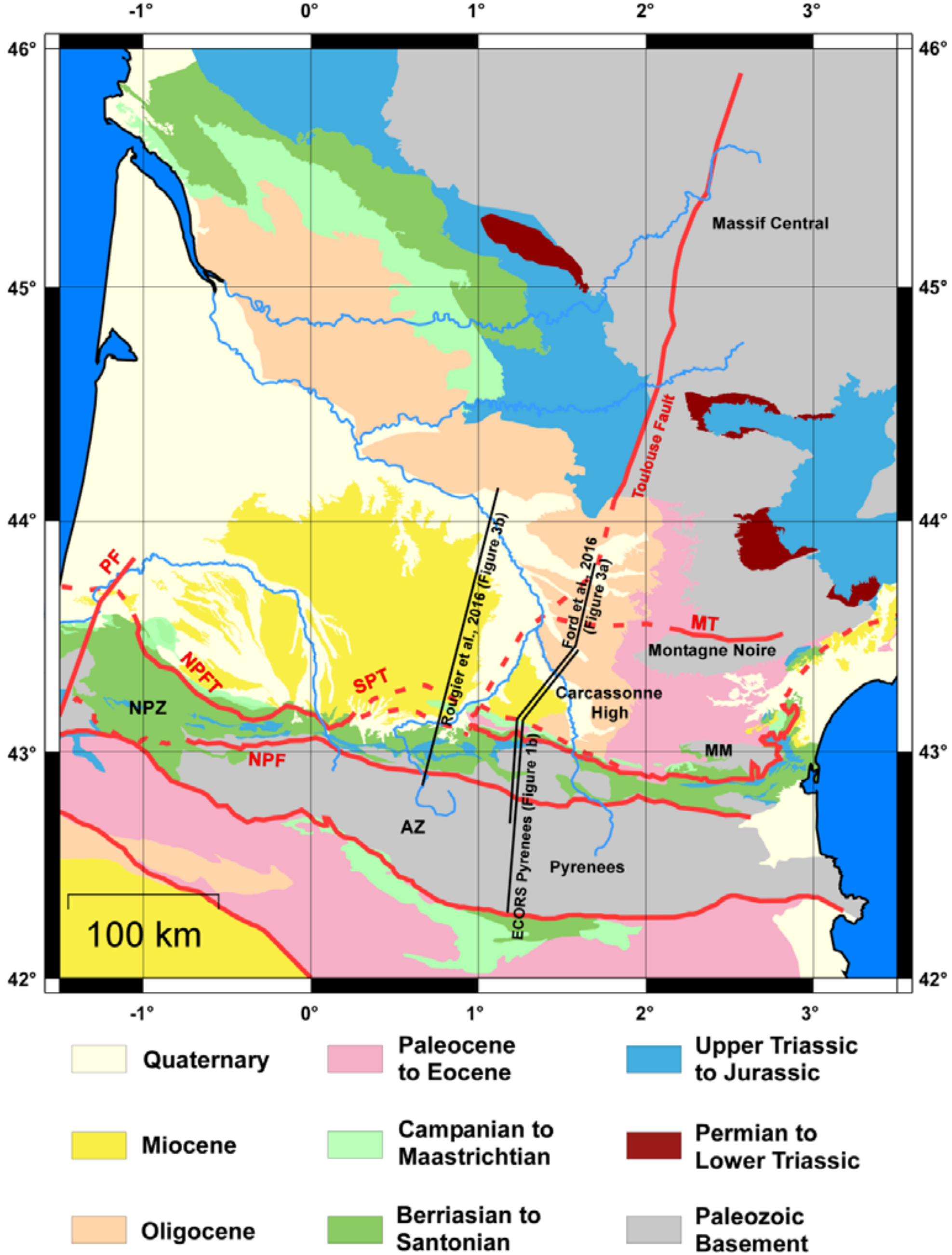

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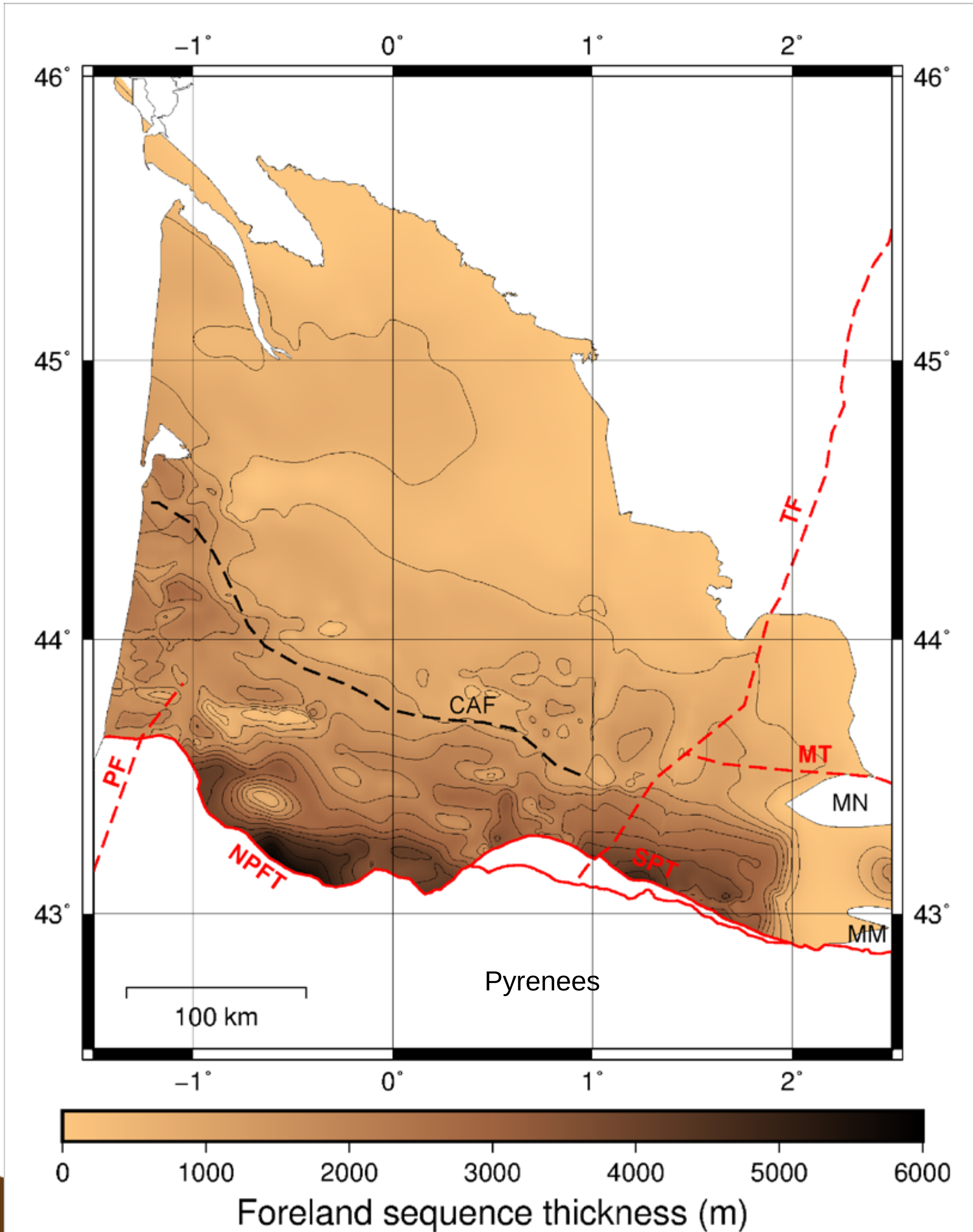
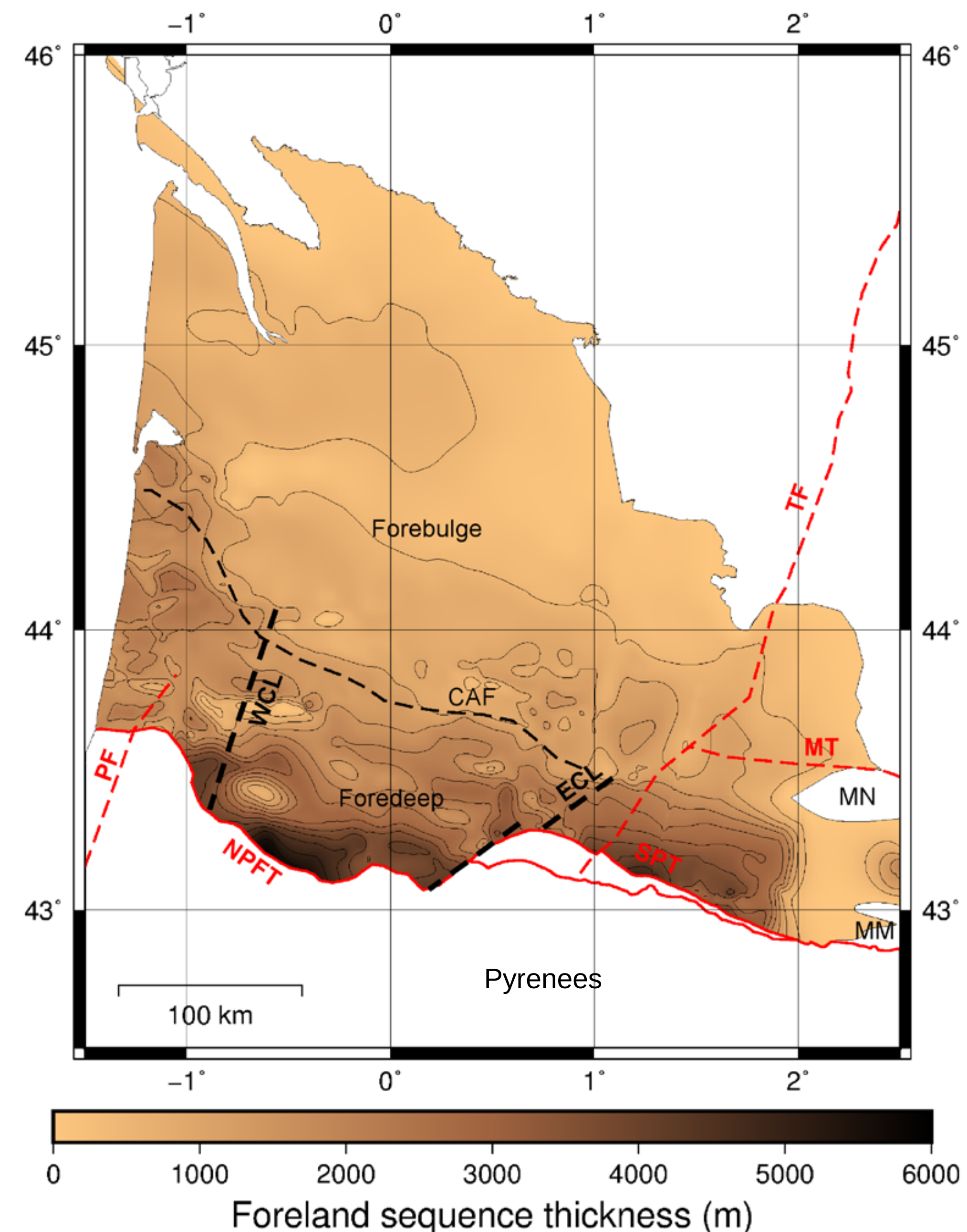


- Campanian to Miocene
- Data:
  - Isopach maps (BRGM et al., 1974)
  - PYRAMID cross-sections (Ford et al., 2016; Rougier et al., 2016; Espurt et al., in prep., Ford et al., in prep.; Grool et al., in prep.)
- Thickening southward (up to 5.5 km thick)
- Flexure of ~150 km wide and bulge of 20-50 km wide

Angrand et al., in prep.

The Aquitaine foreland basin | Foreland distribution



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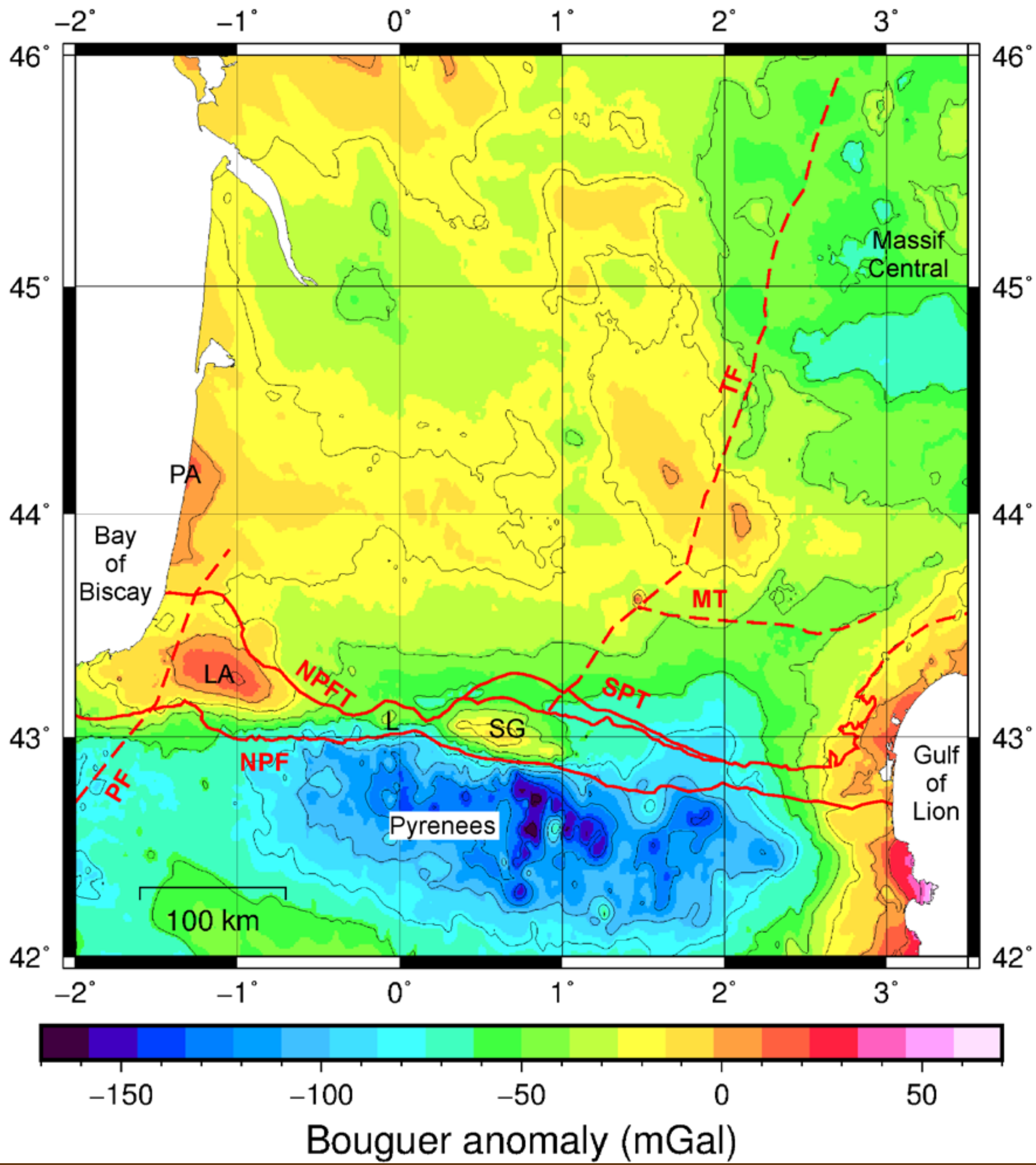
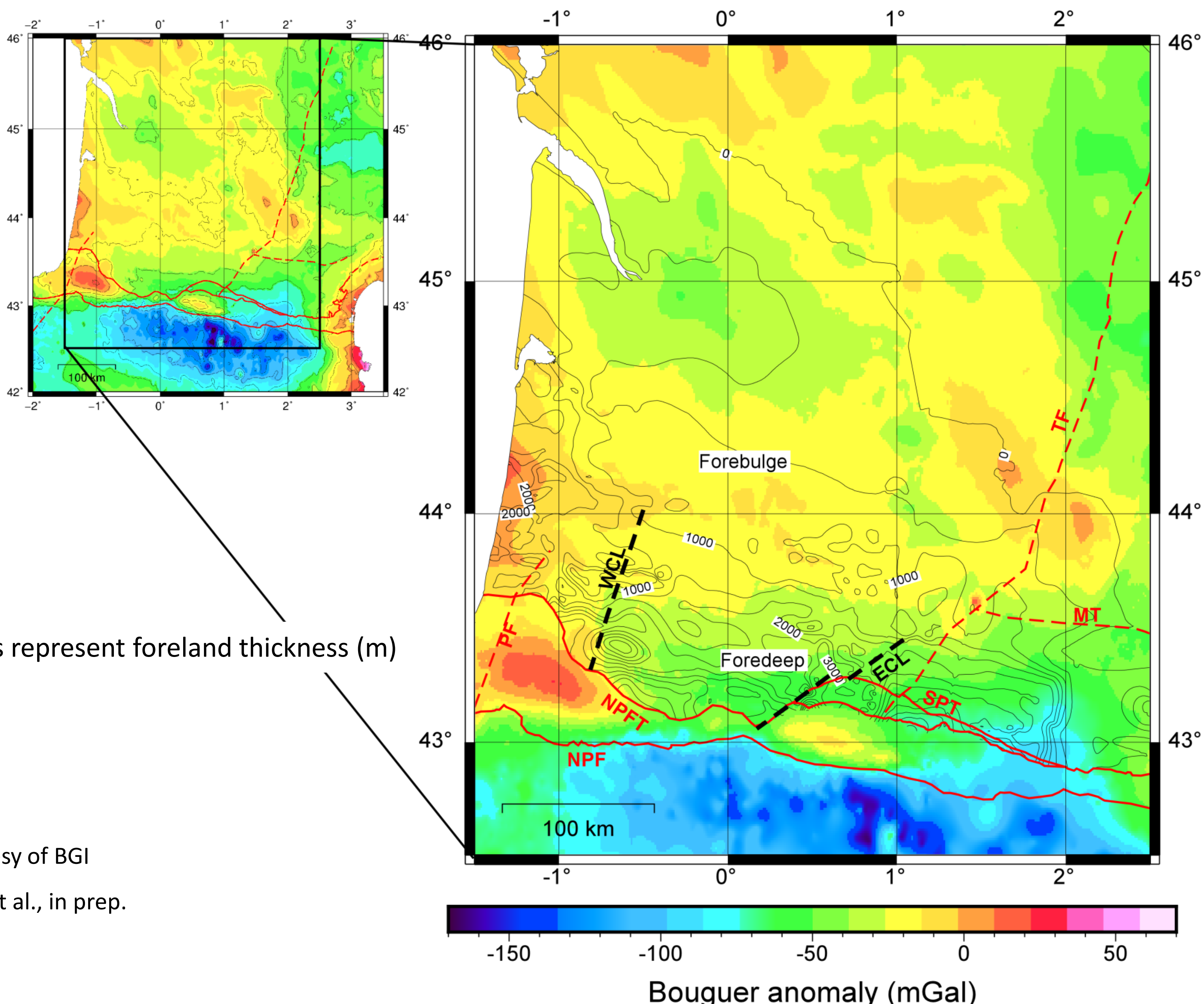


Courtesy of BGI

Angrand et al., in prep.

The Aquitaine foreland basin | Bouguer anomaly

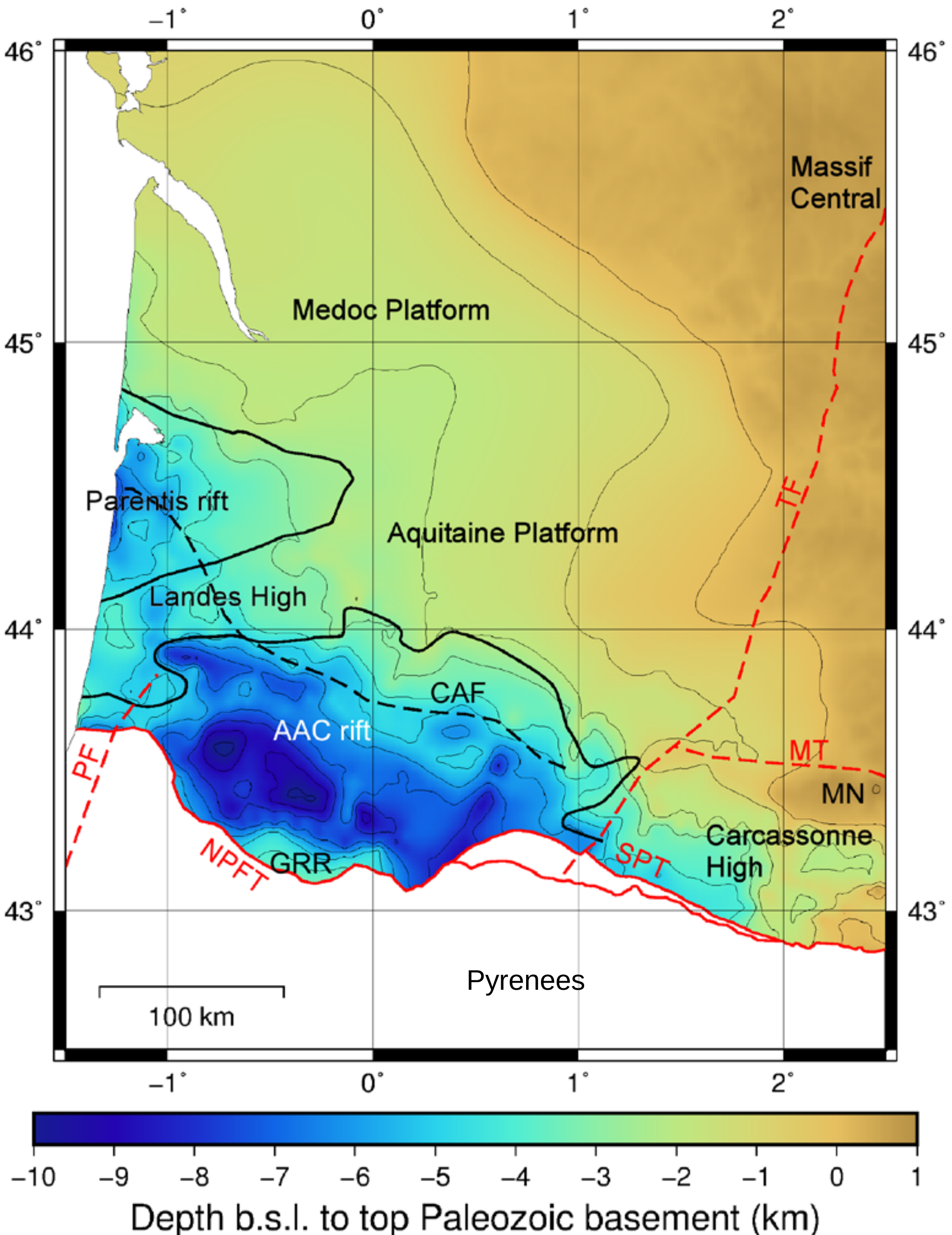


Isolines represent foreland thickness (m)

Courtesy of BGI

Angrand et al., in prep.

Crustal template | Depth of top Paleozoic basement



- Observed top Paleozoic basement
- Data:
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  - Seismic profiles (Serrano et al., 2006)
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Angrand et al., in prep.

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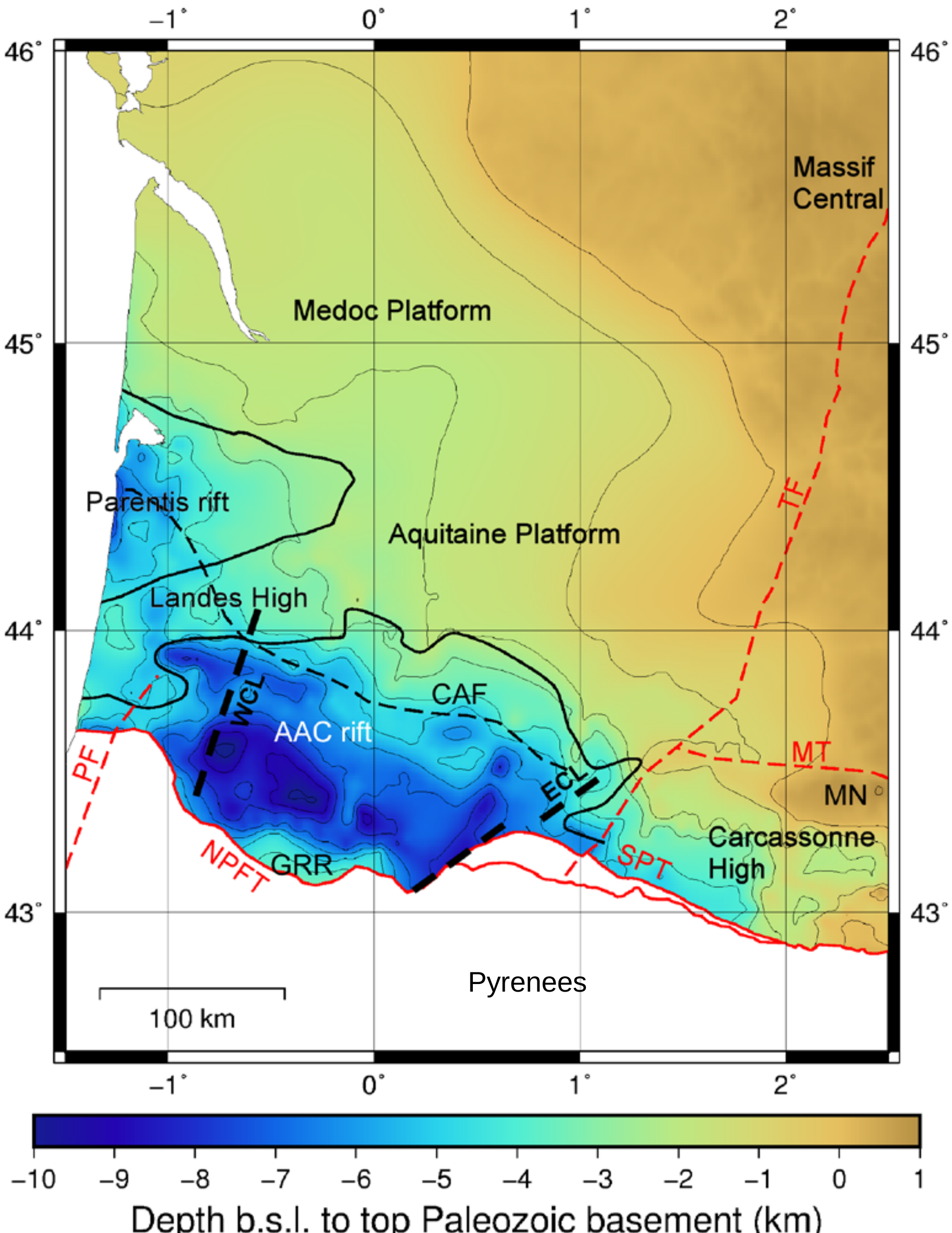

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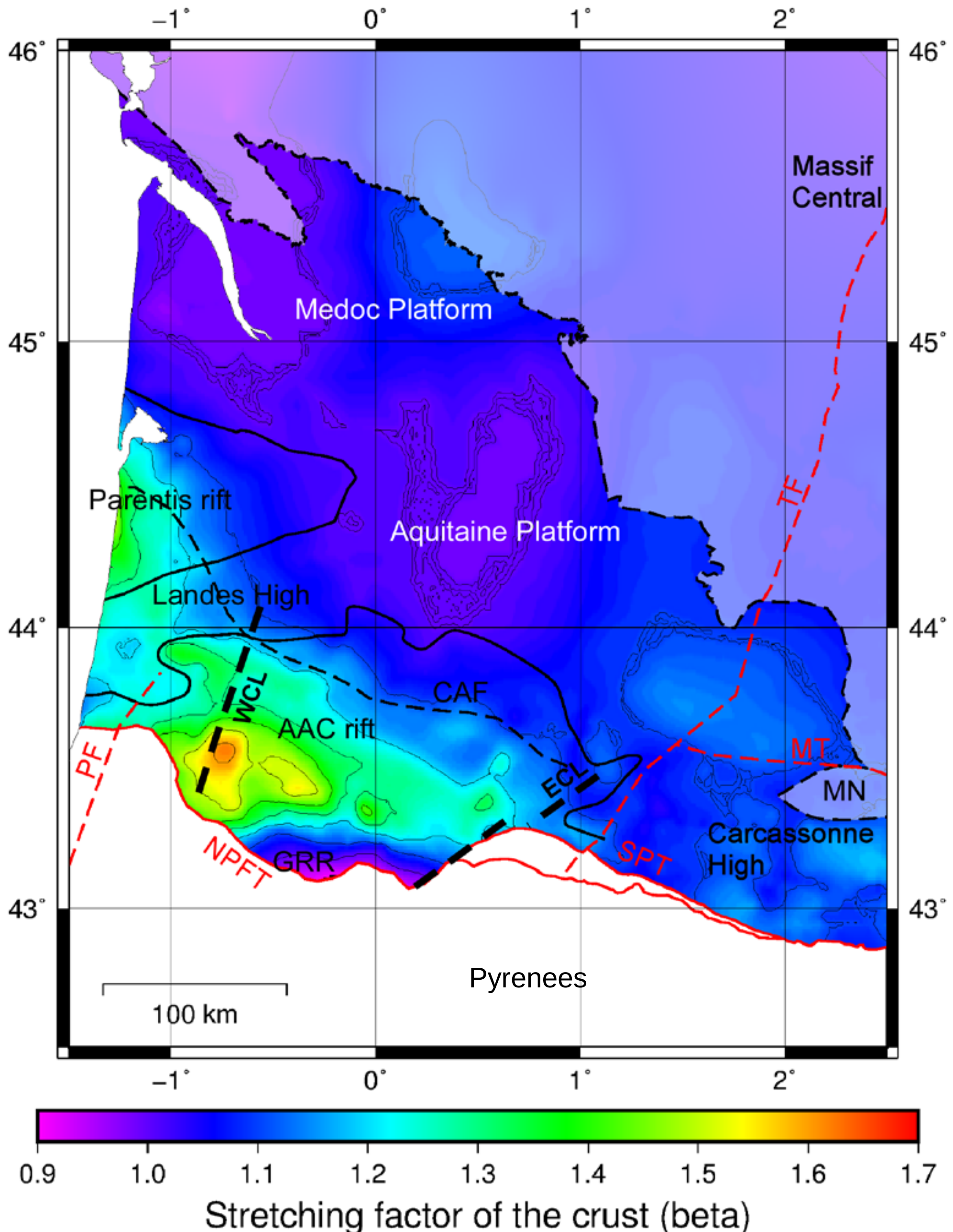
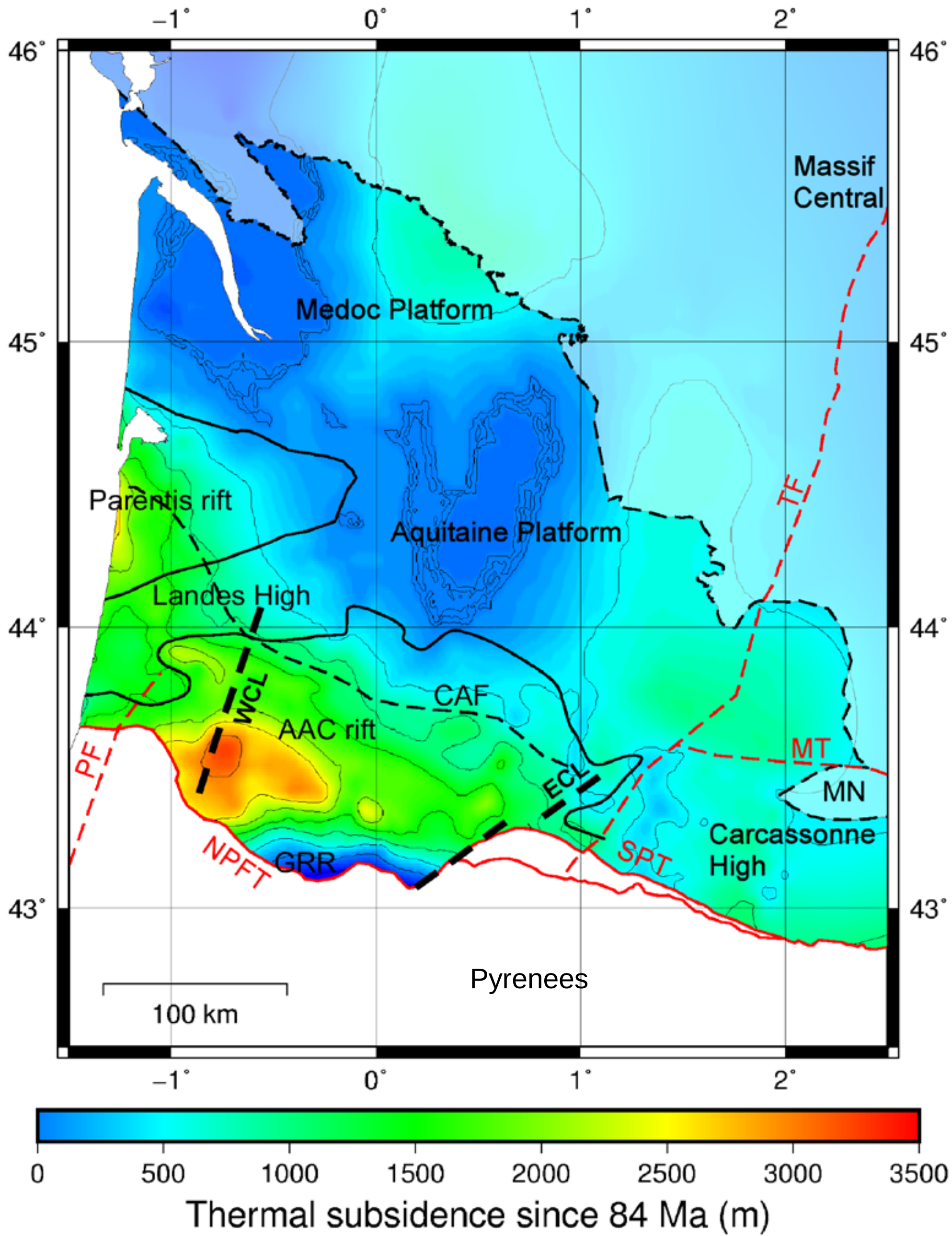


- Top of the crust: depth to top Paleozoic basement
- Base of the crust: depth to Moho, compilation of seismic data (Navarro et al., 2006)
- Initial crustal thickness: 33 km (from the platform)

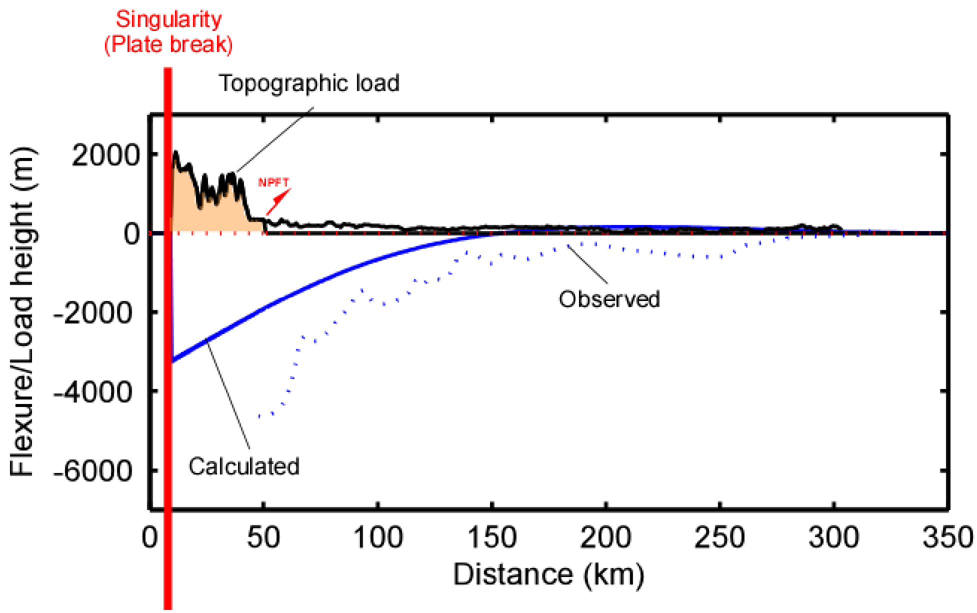
$$\beta = \frac{initial\ crustal\ thickness}{final\ crustal\ thickness}$$

Angrand et al., in prep.



- Thermal subsidence during the Pyrenean orogeny (since 84 Ma)
- Uniform Stretching Model (McKenzie, 1978)
- Sediment-filled basin (2500 kg.m^{-3})
- Pre-rift lithospheric thickness: 125 km
- Thermal constant of the lithosphere: 50 Myr

Angrand et al., in prep.



- Broken plate conditions

- Fixed physical parameters:

  Young's modulus: 100 Gpa

  Poisson's ratio: 0.25

  Density of topographic load: 2700 kg.m^{-3}

  Density of sediments: 2500 kg.m^{-3}

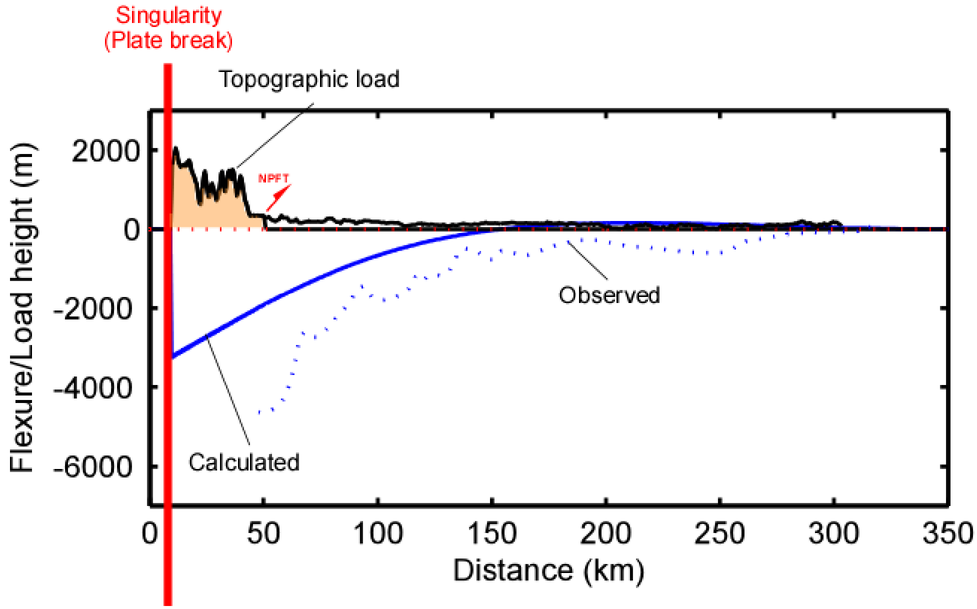
  Density of mantle: 3200 kg.m^{-3}

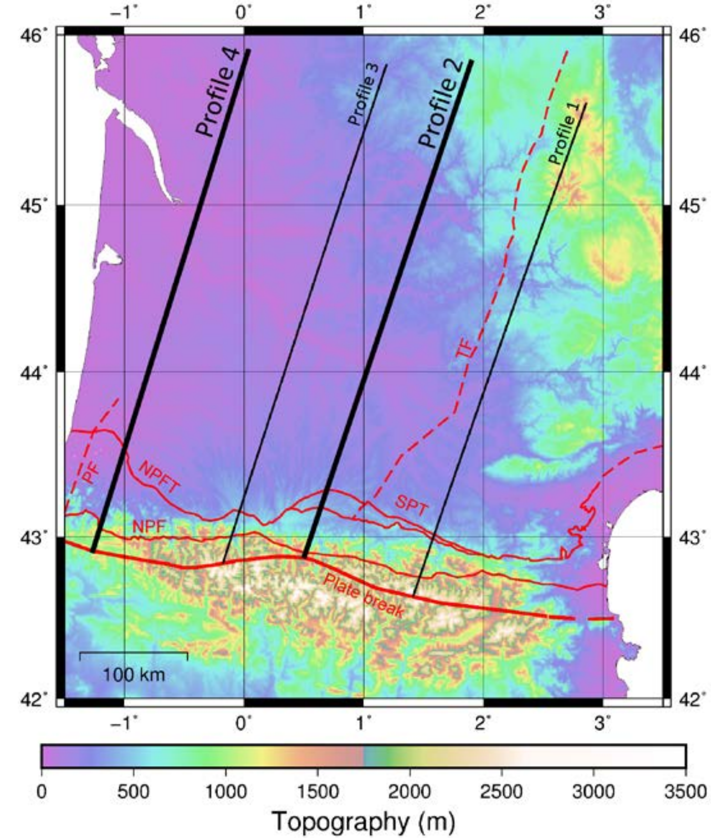
- Varying Te:

  Te is constant or varies along the profile

  Te varies along strike

- We compare the calculated flexure to the observed base of foreland surface





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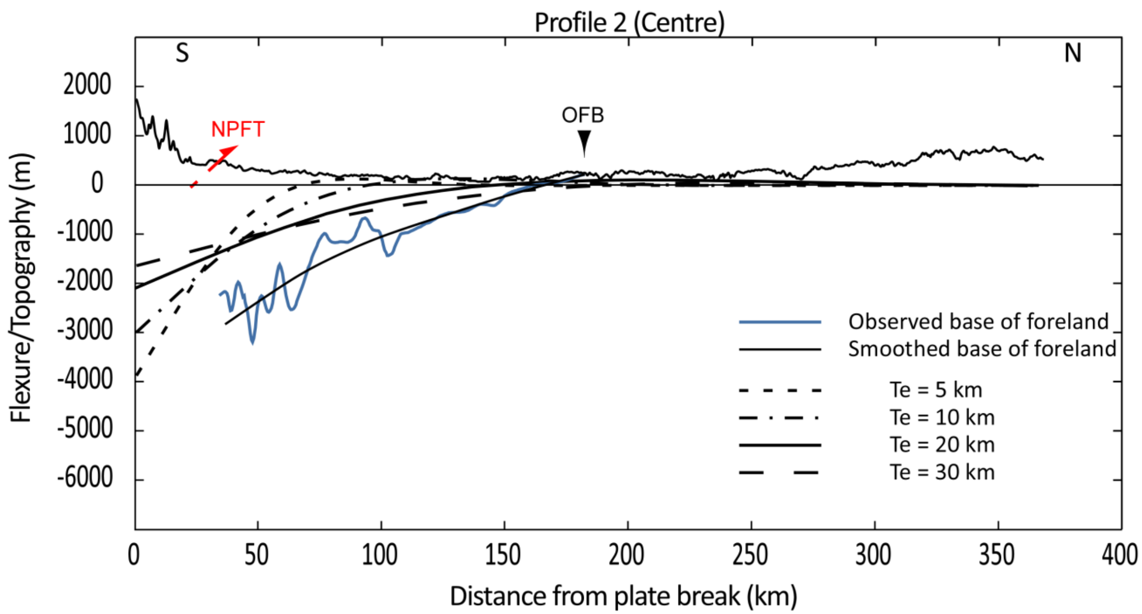
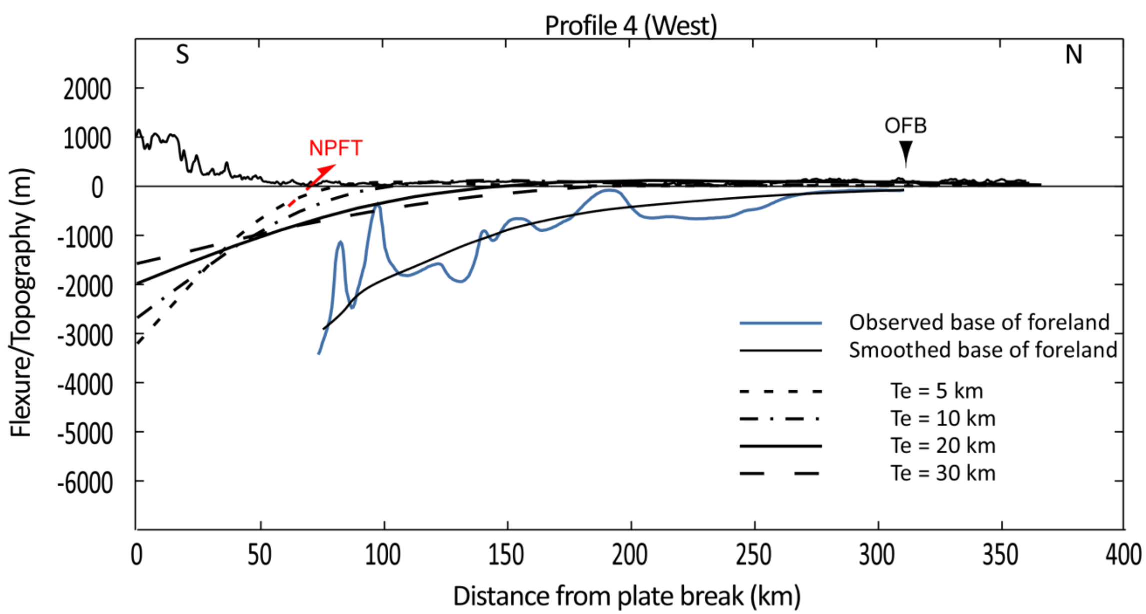
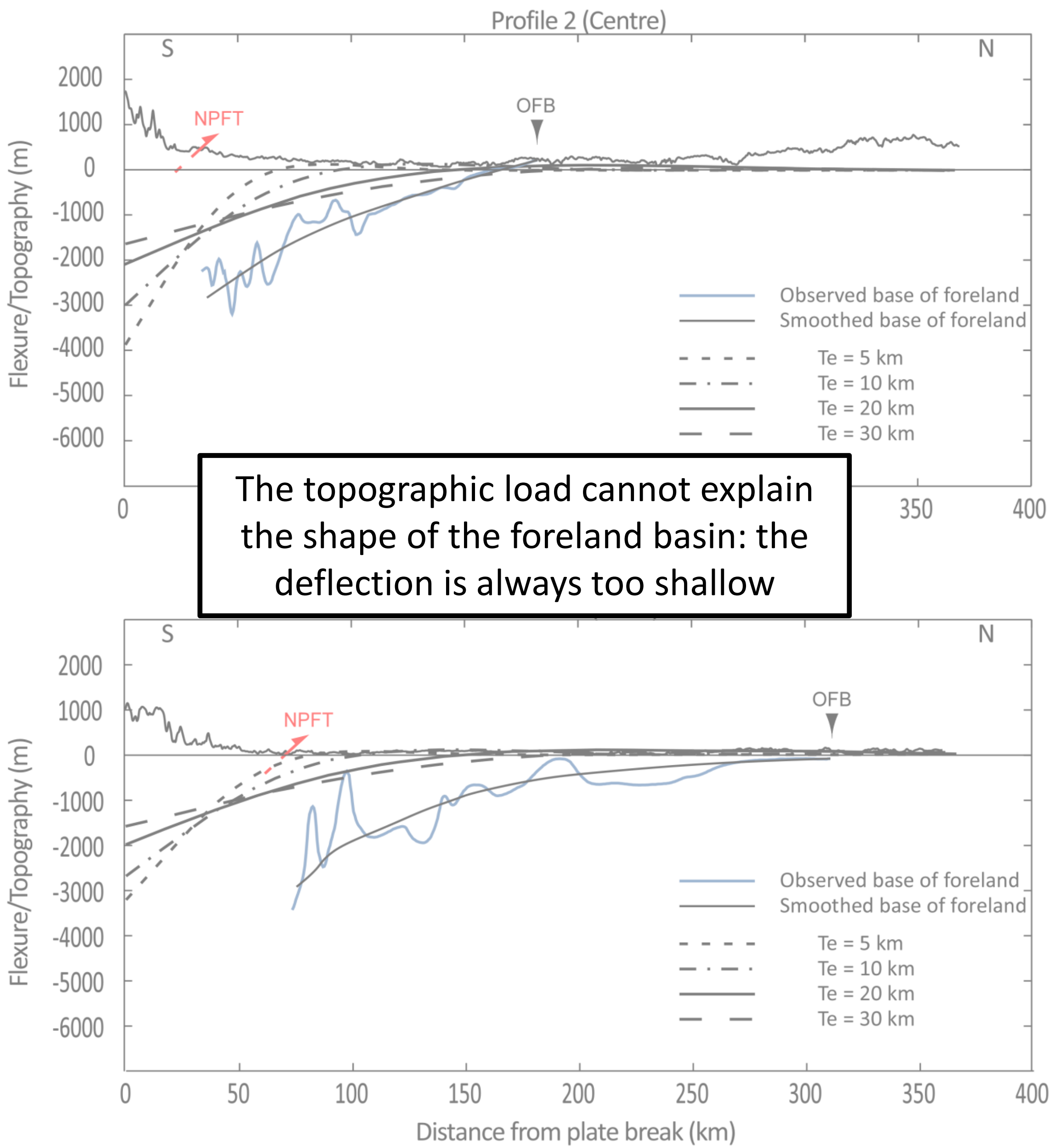




Angrand et al., in prep.

Results | Flexure due to topography



The topographic load cannot explain the shape of the foreland basin: the deflection is always too shallow

Angrand et al., in prep.

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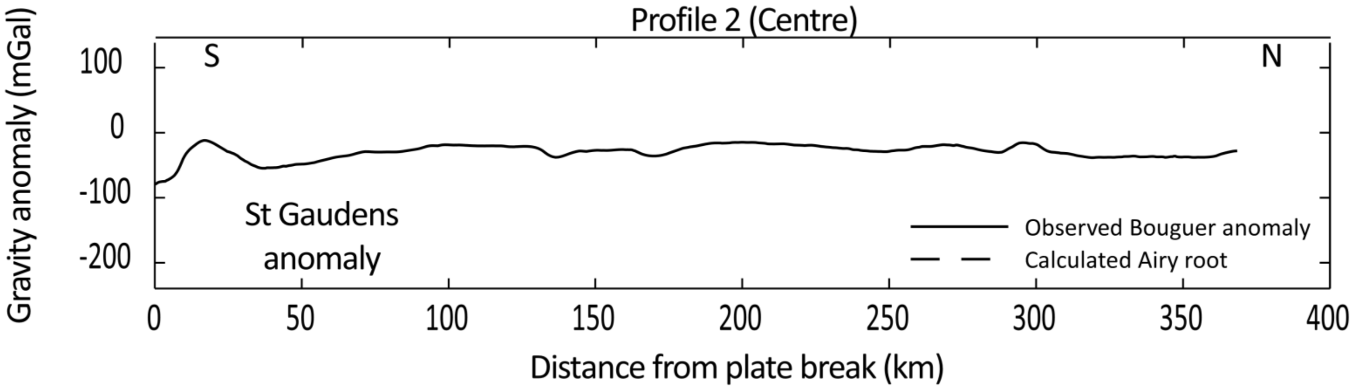

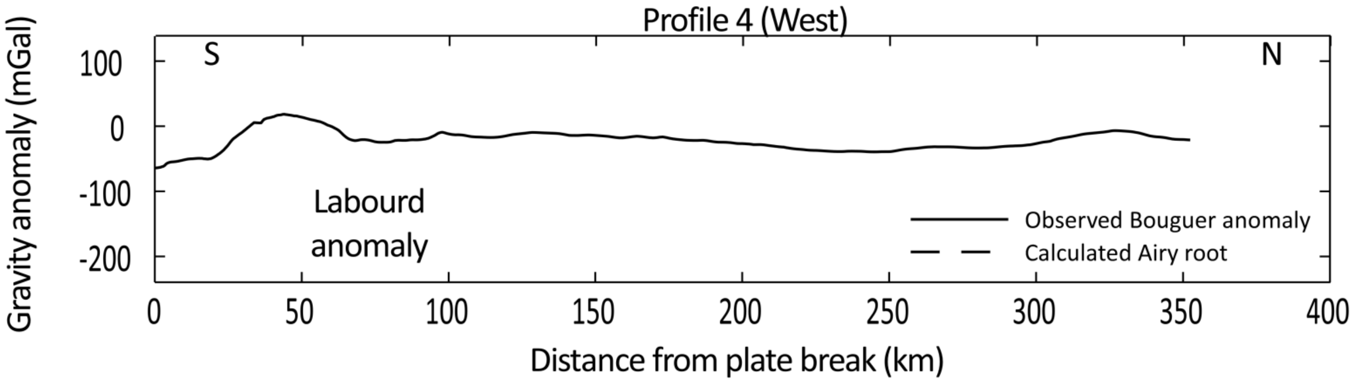

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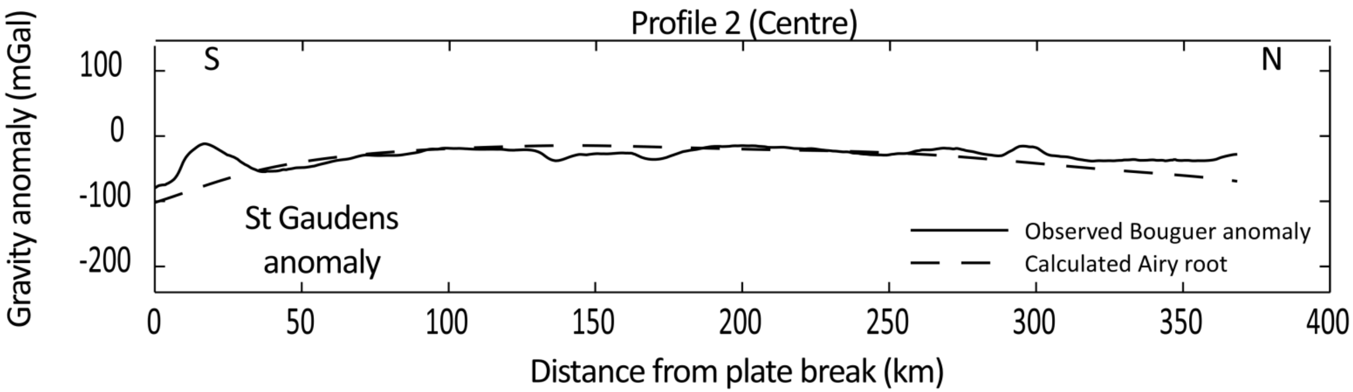

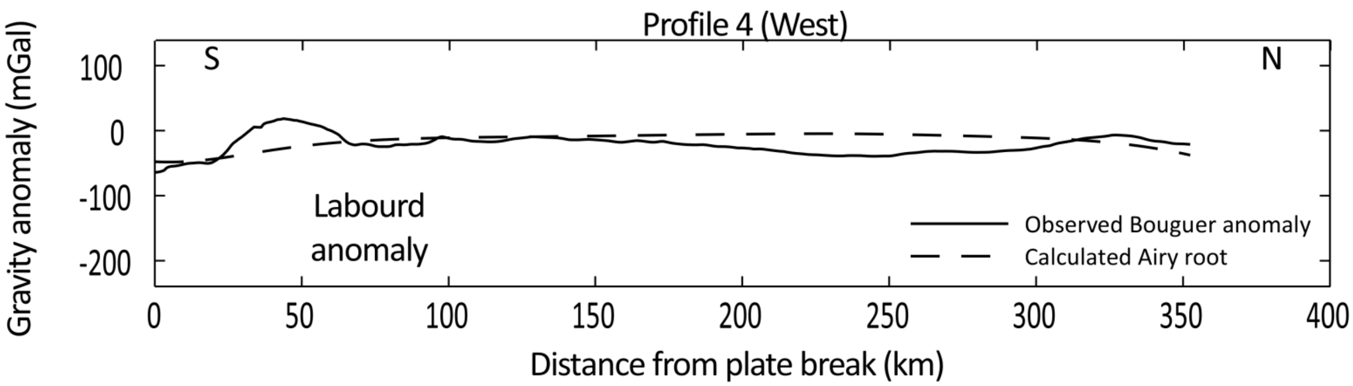

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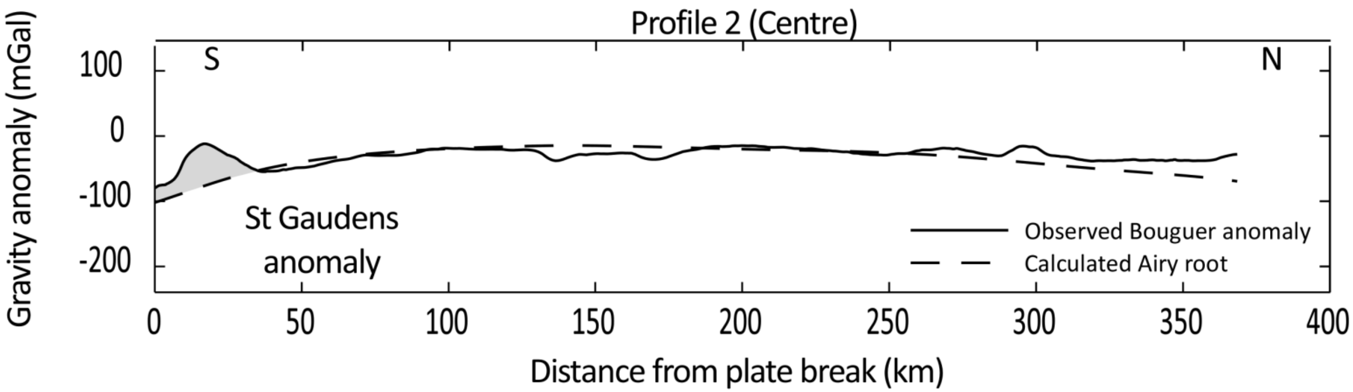

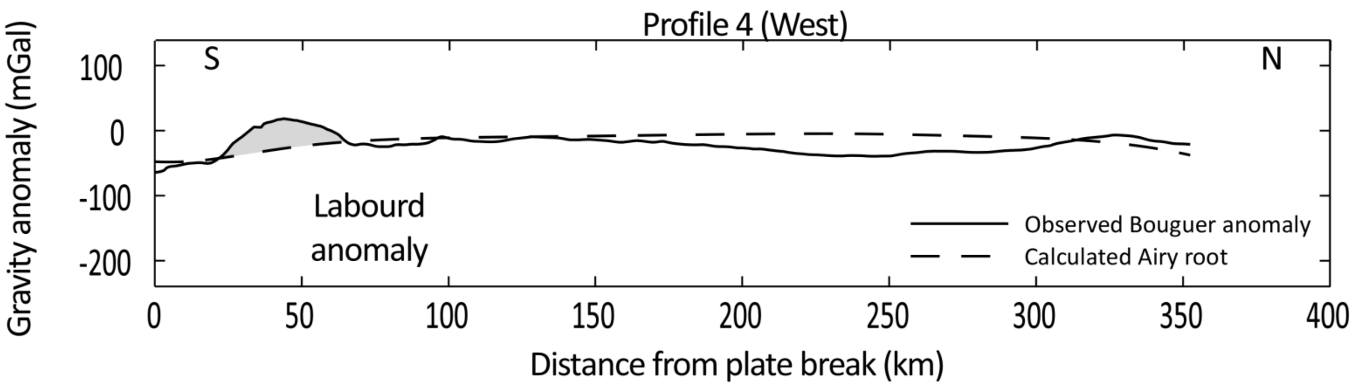

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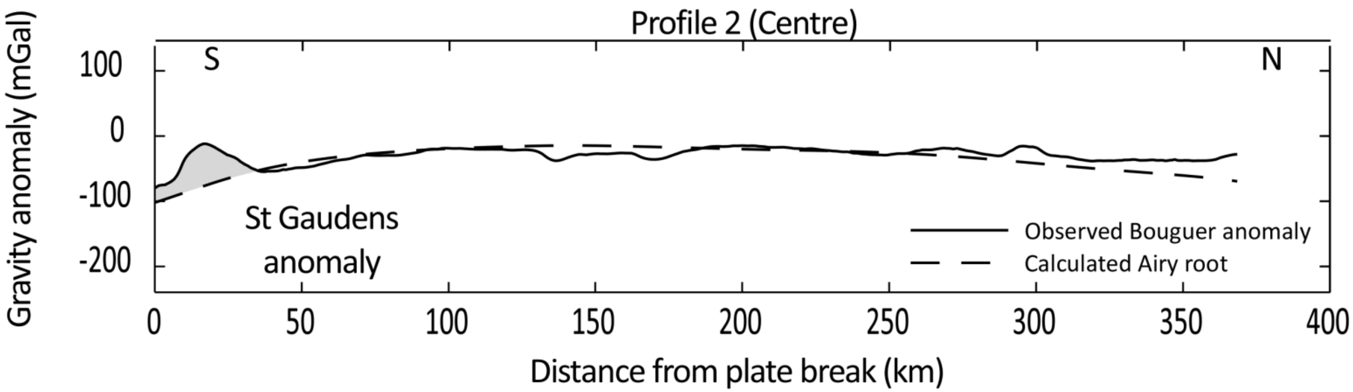
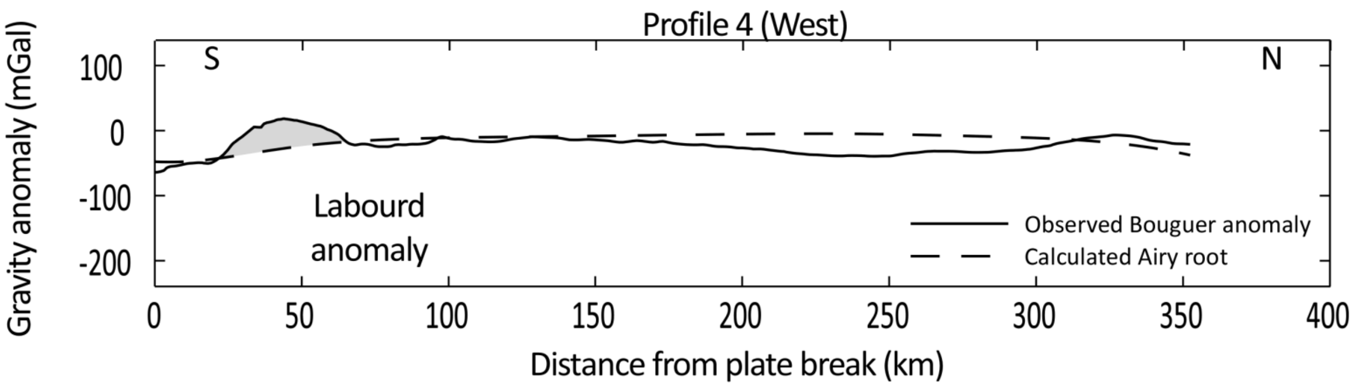




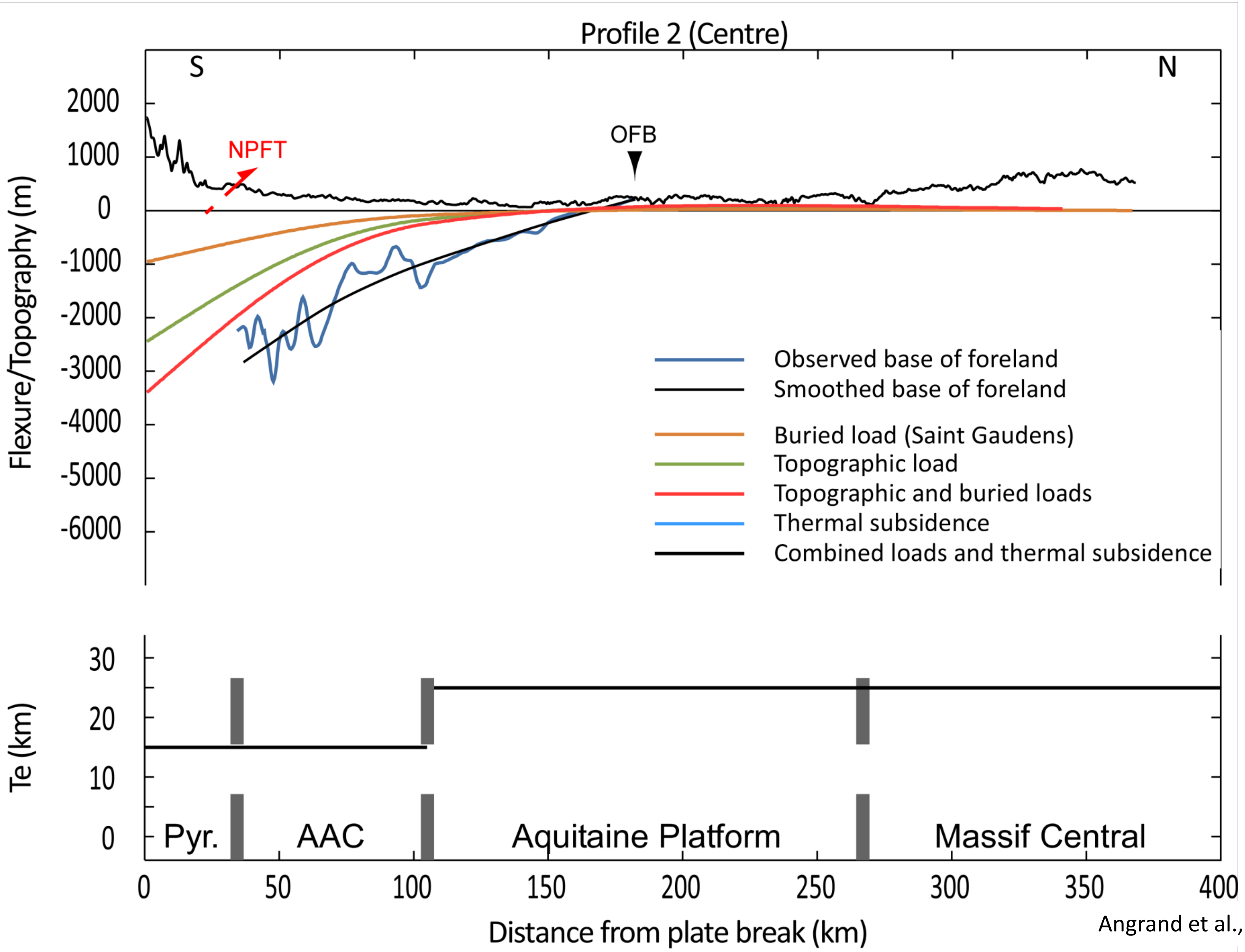
Green equivalent layer theorem:

$$H = \frac{\Delta g_{Airy}}{2\pi G \Delta\rho_b}$$

Δg_{Airy}: Positive part of The Airy isostatic anomaly

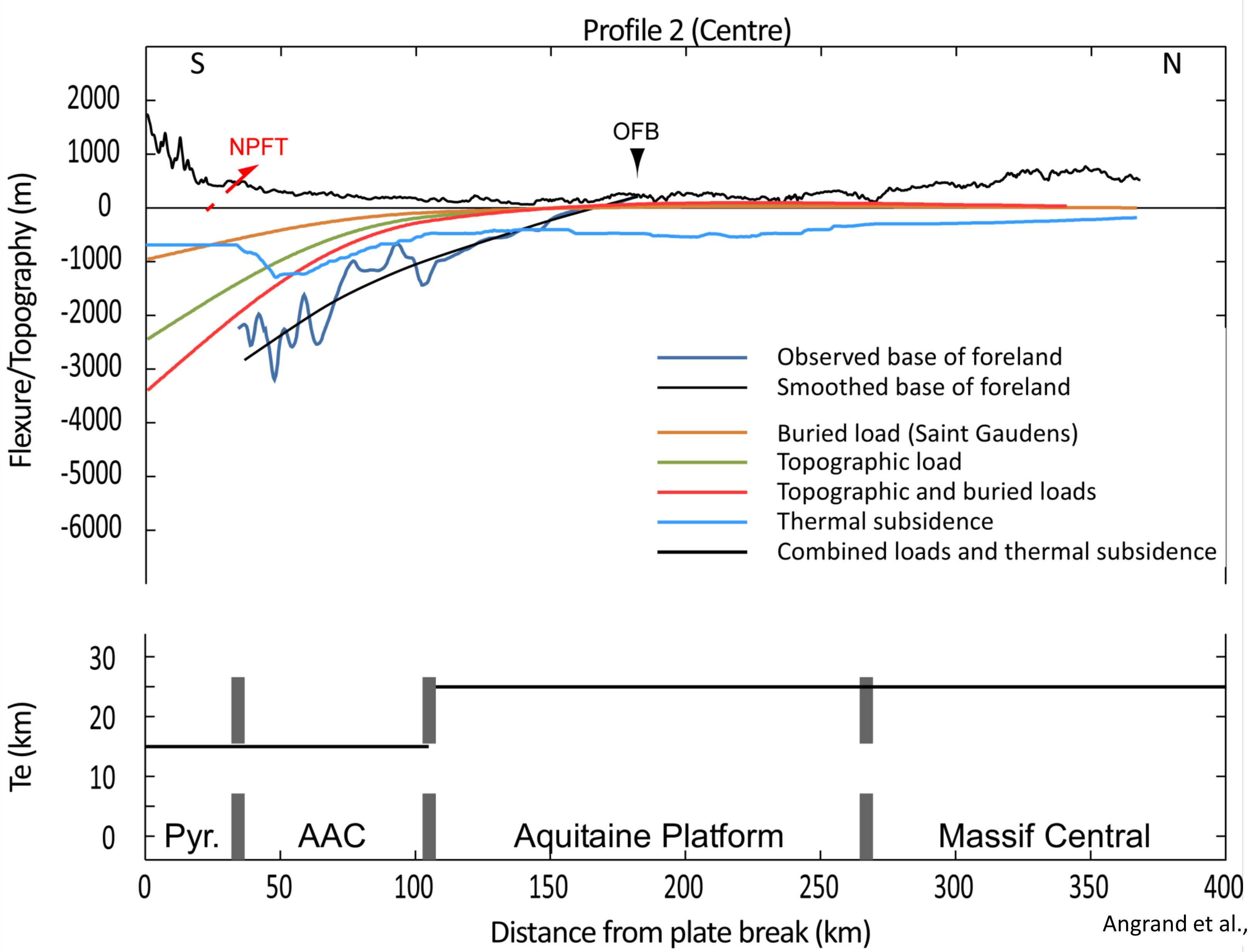
$\Delta\rho_b$: Density contrast: 500 kg.m^{-3}

Angrand et al., in prep.



Angrand et al., in prep.

Results | Combined subsidence: Central Aquitaine Basin



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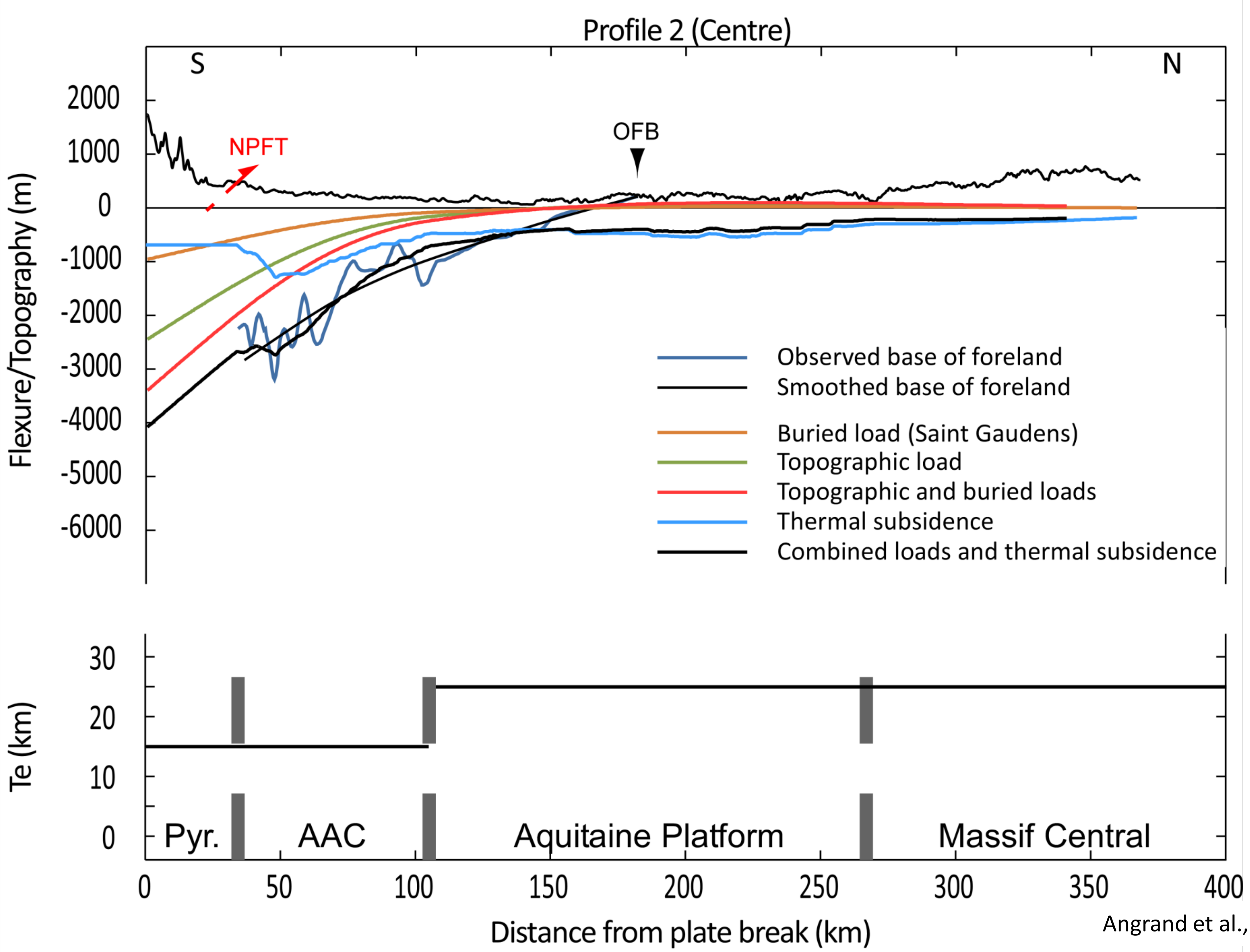

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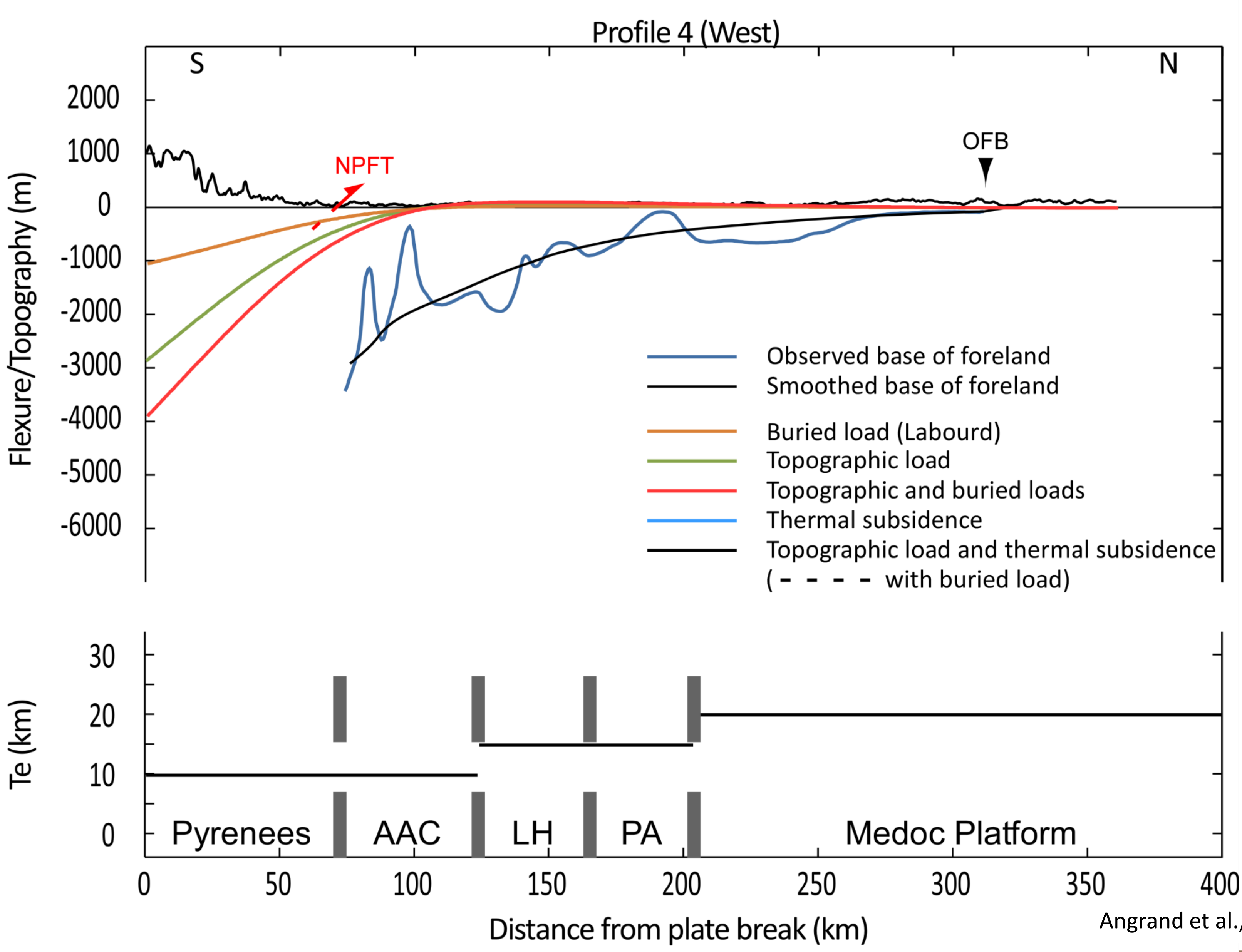
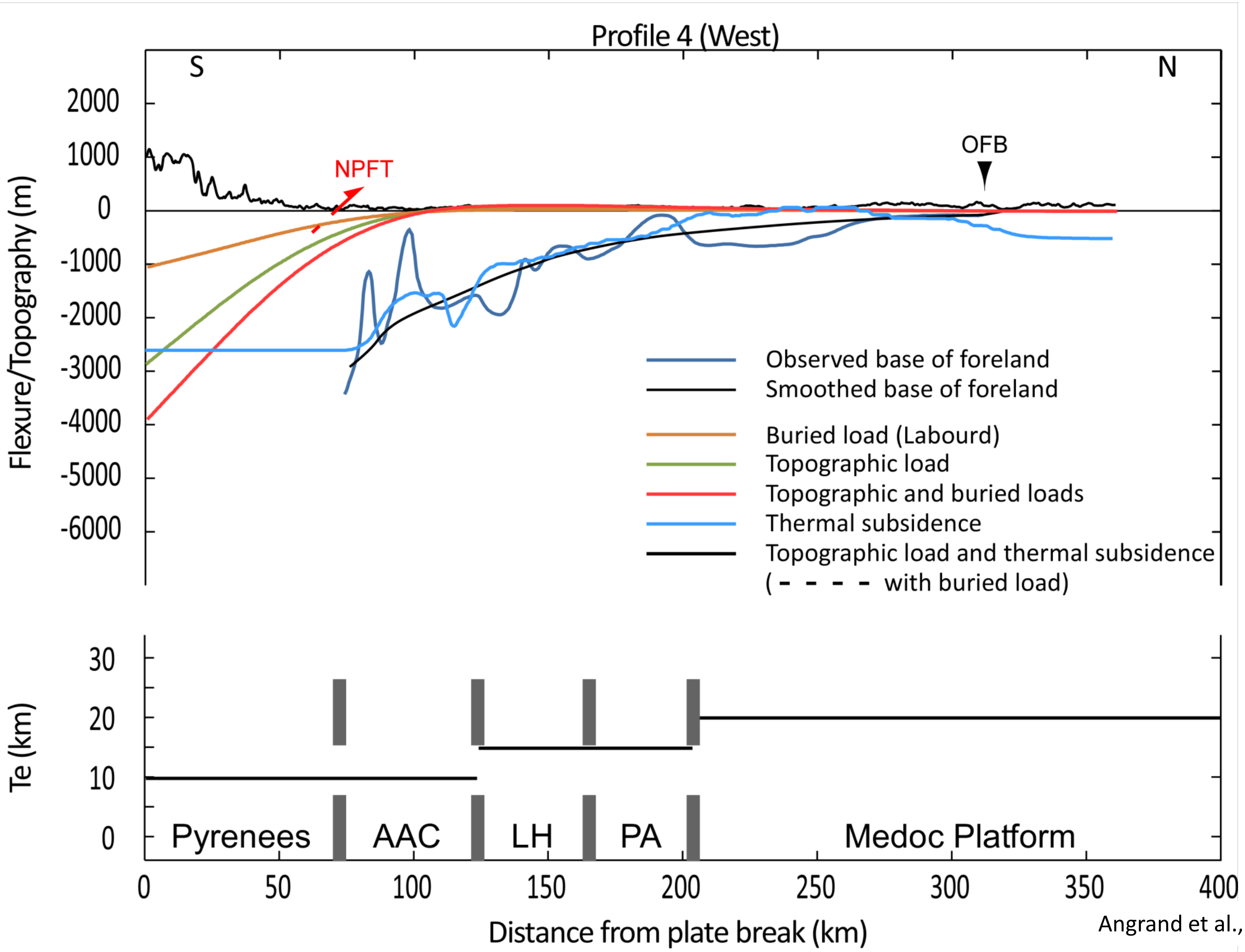


Angrand et al., in prep.

Results | Combined subsidence: Western Aquitaine Basin



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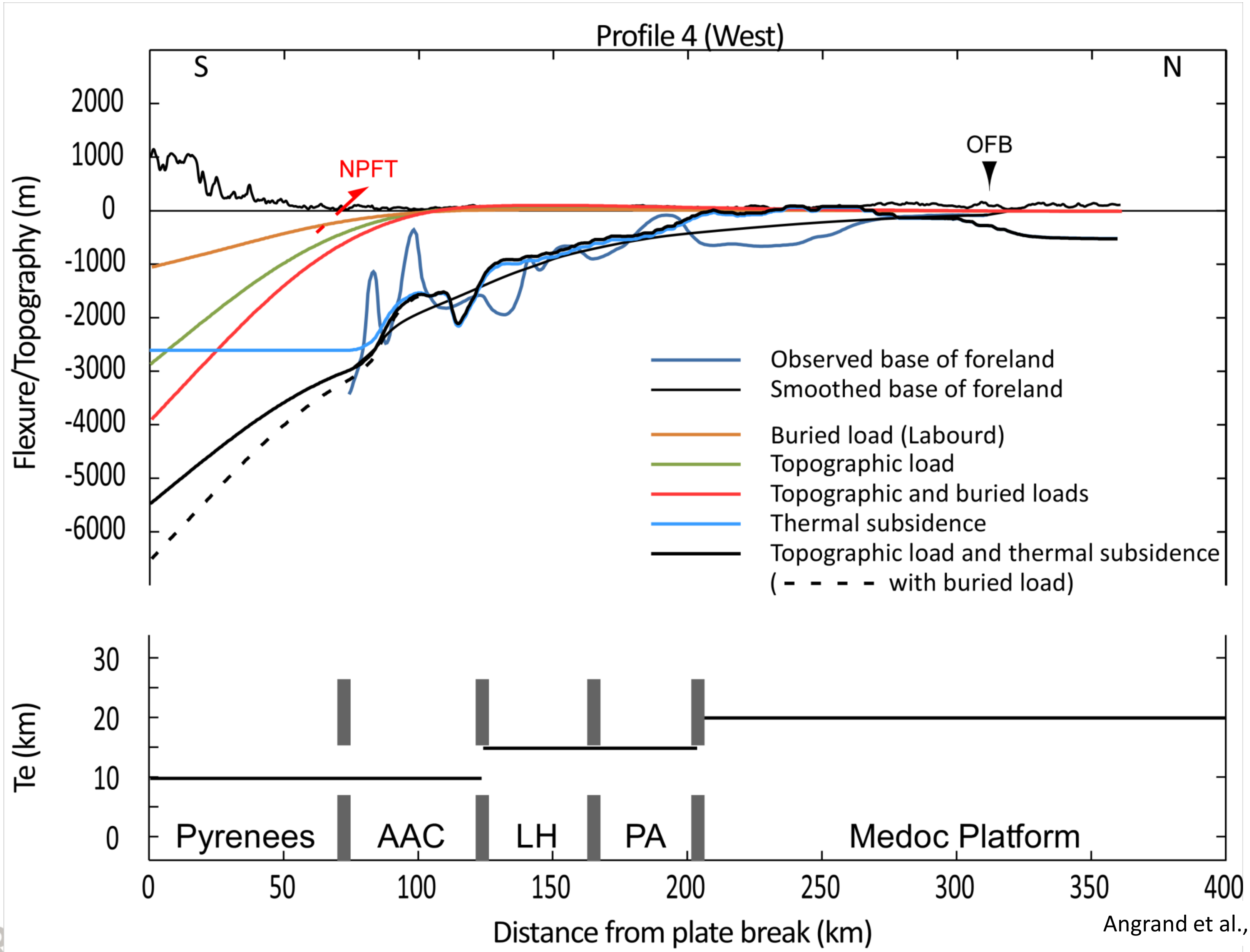

Angrand et al., in prep.

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    - Strong segmentation of both basement and foreland
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  - What about the Labourd gravity anomaly?

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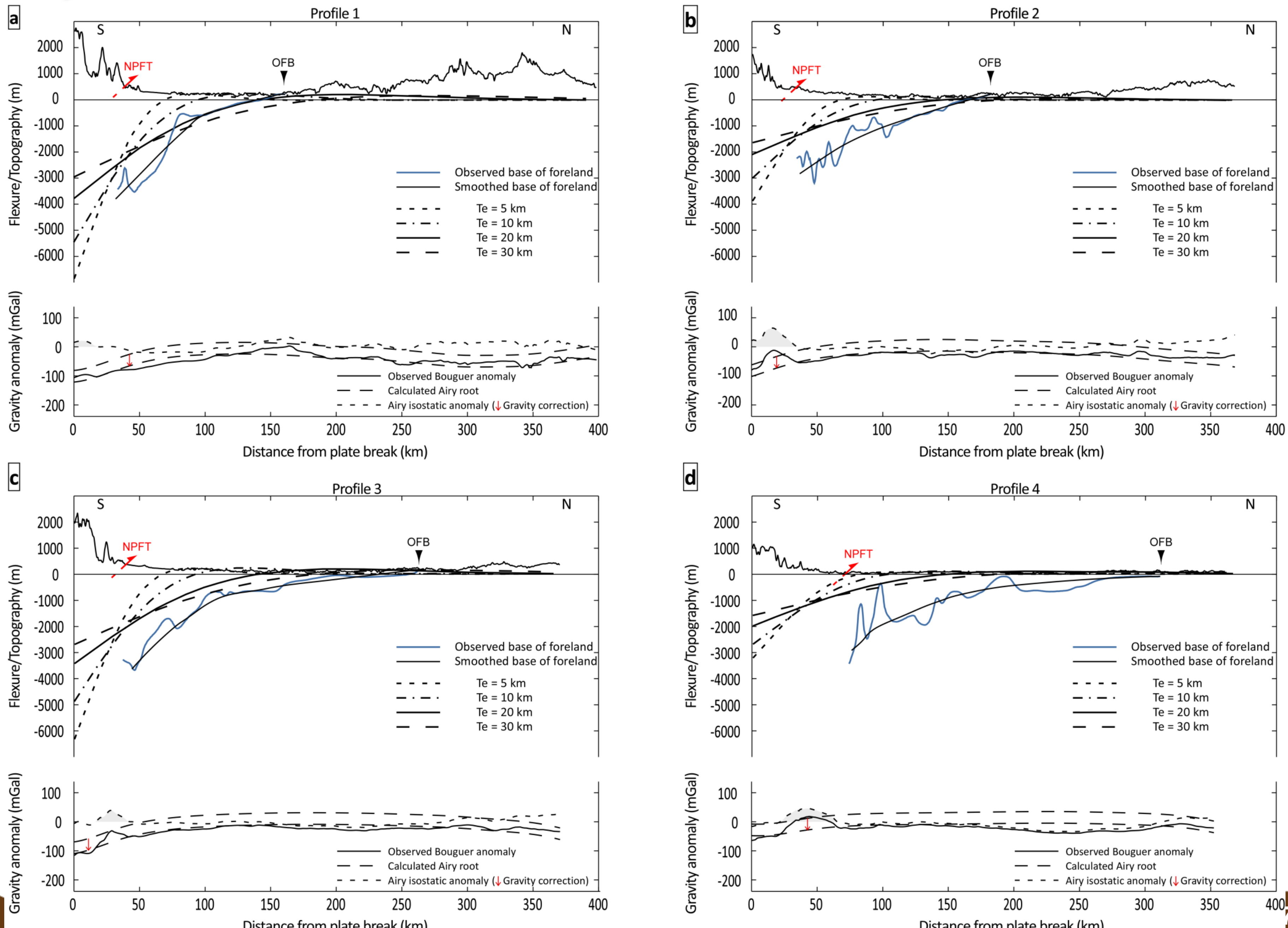
  - In the westernmost Aquitaine Basin, the foreland basin geometry is mainly controlled by thermal subsidence
- Controlling factors of the flexure
  - Loading of a rifted crust affects the development of flexural foreland basin (if lithosphere is not thermally equilibrated)
  - In this case, thermal cooling can contribute significantly to subsidence
  - Qualitative correlation between β and Te: the lower the Te, the higher the β

Thanks for your attention

Flexural modelling



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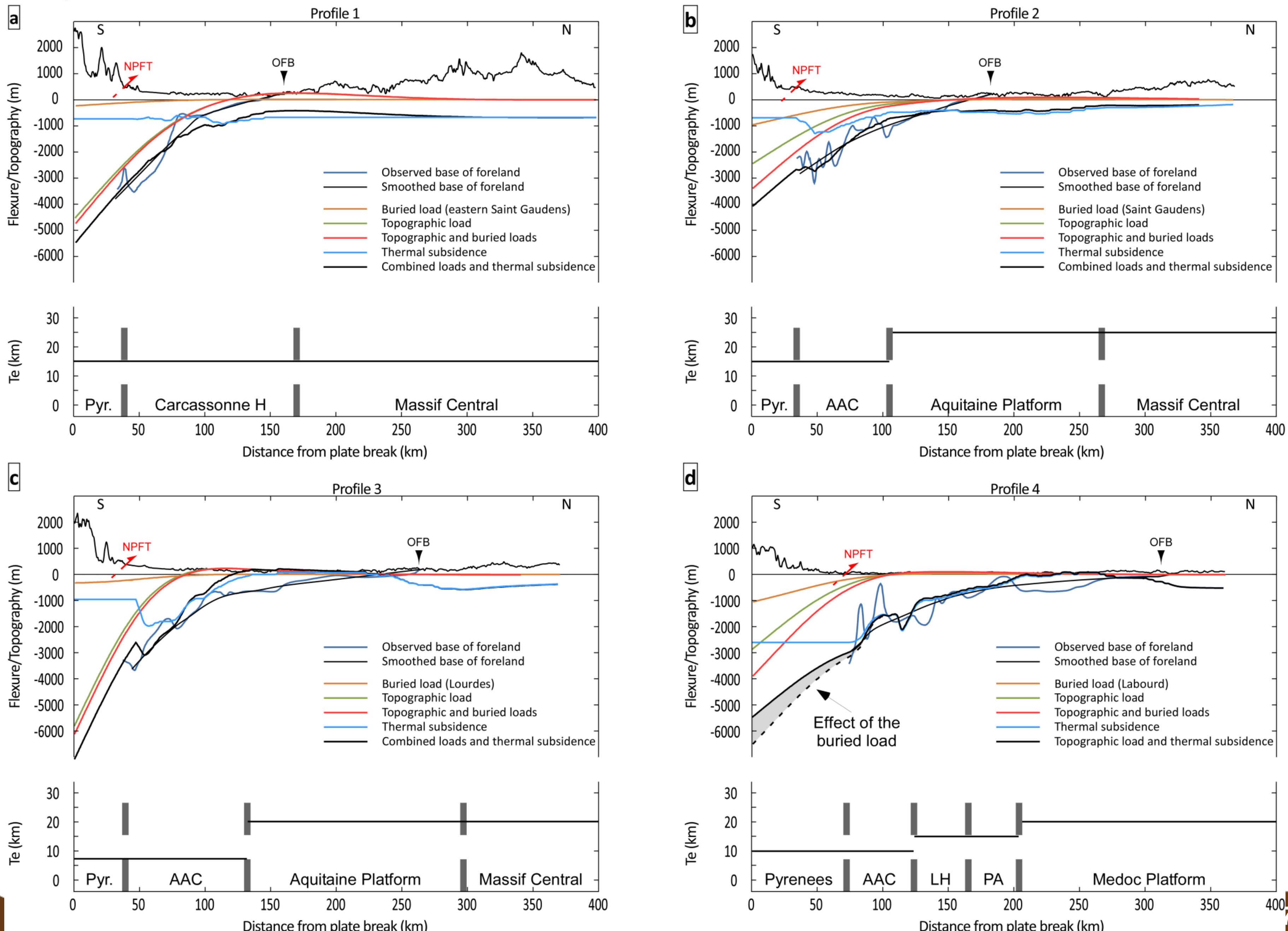
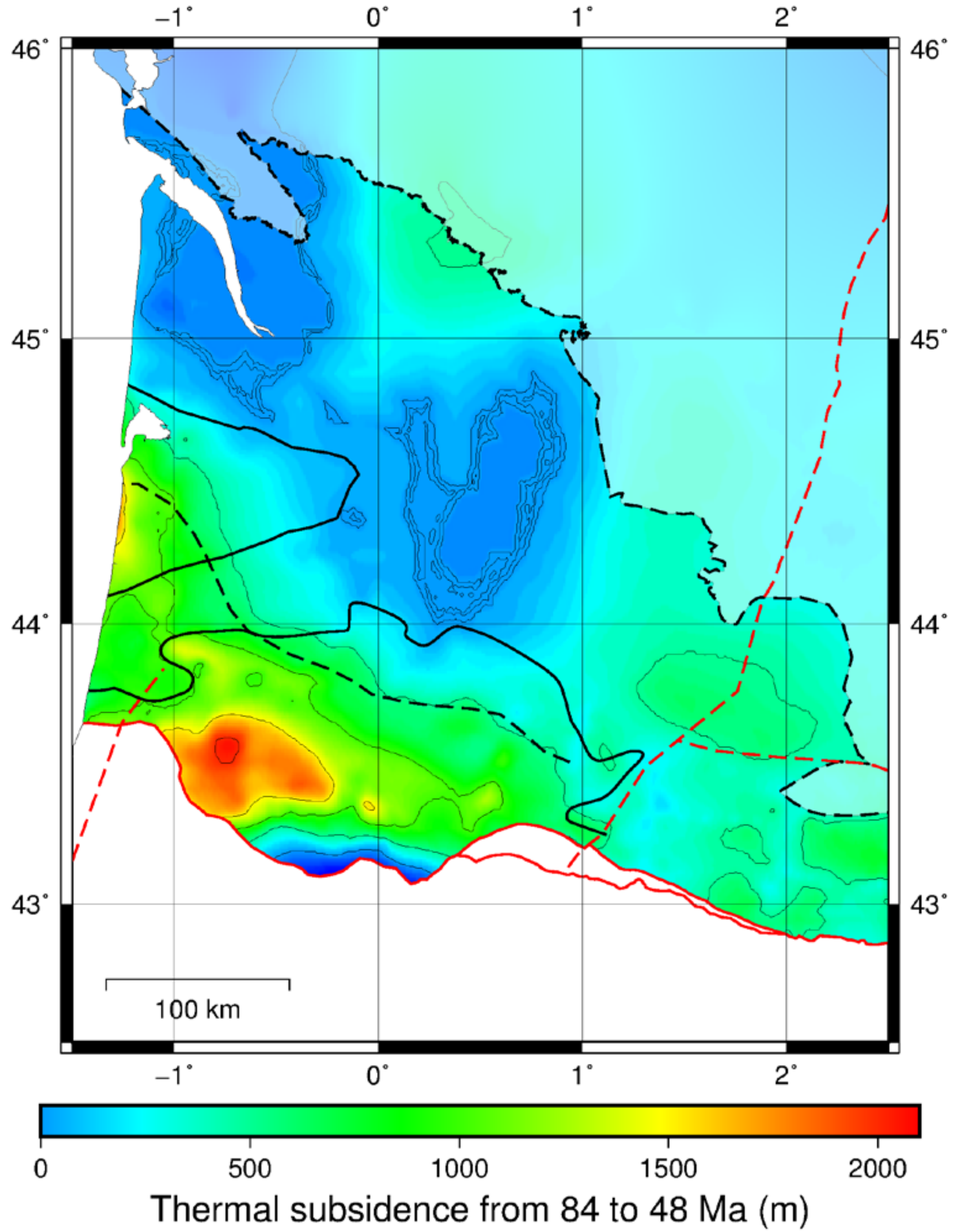
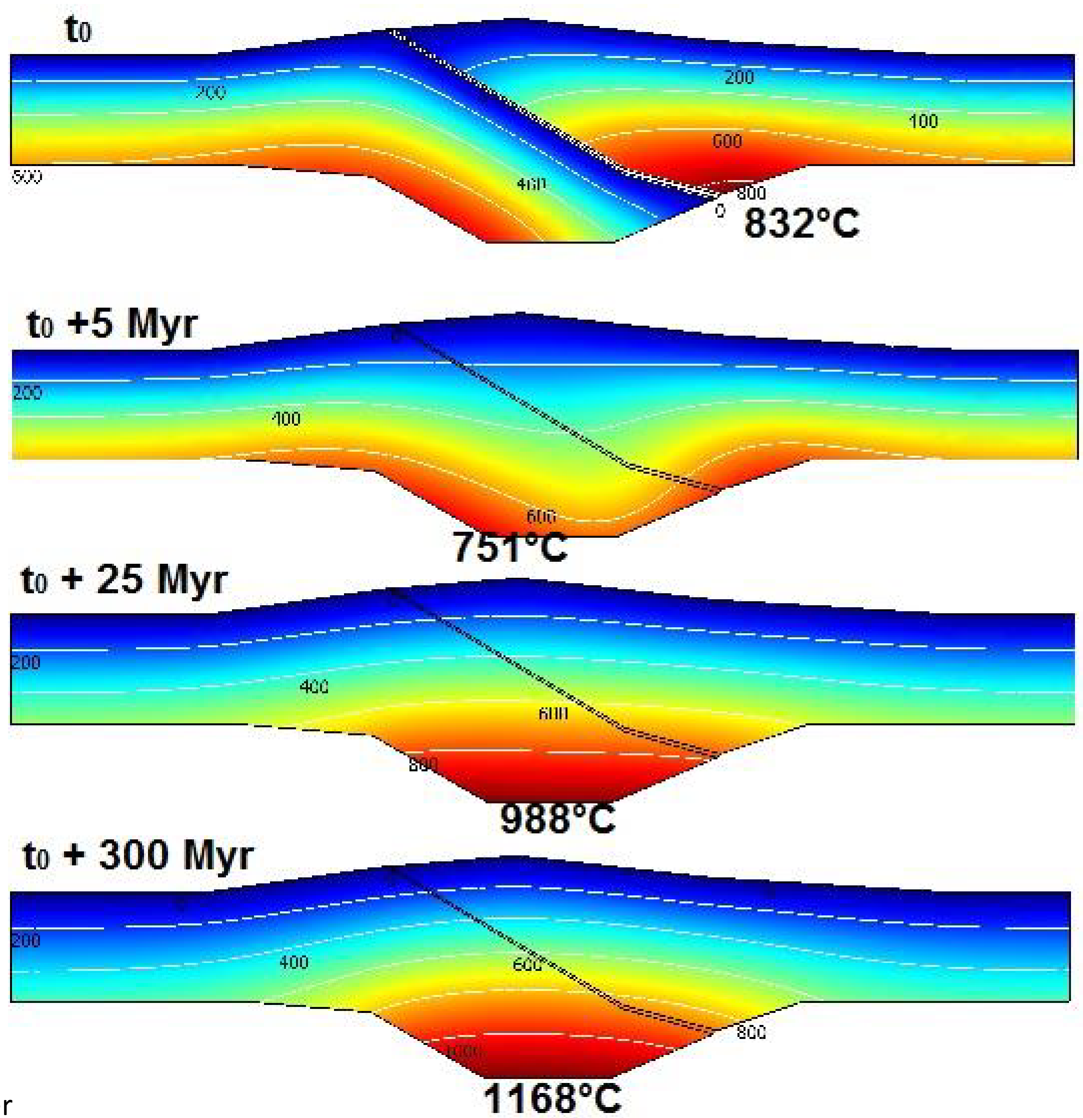


++ | **Thermal subsidence**

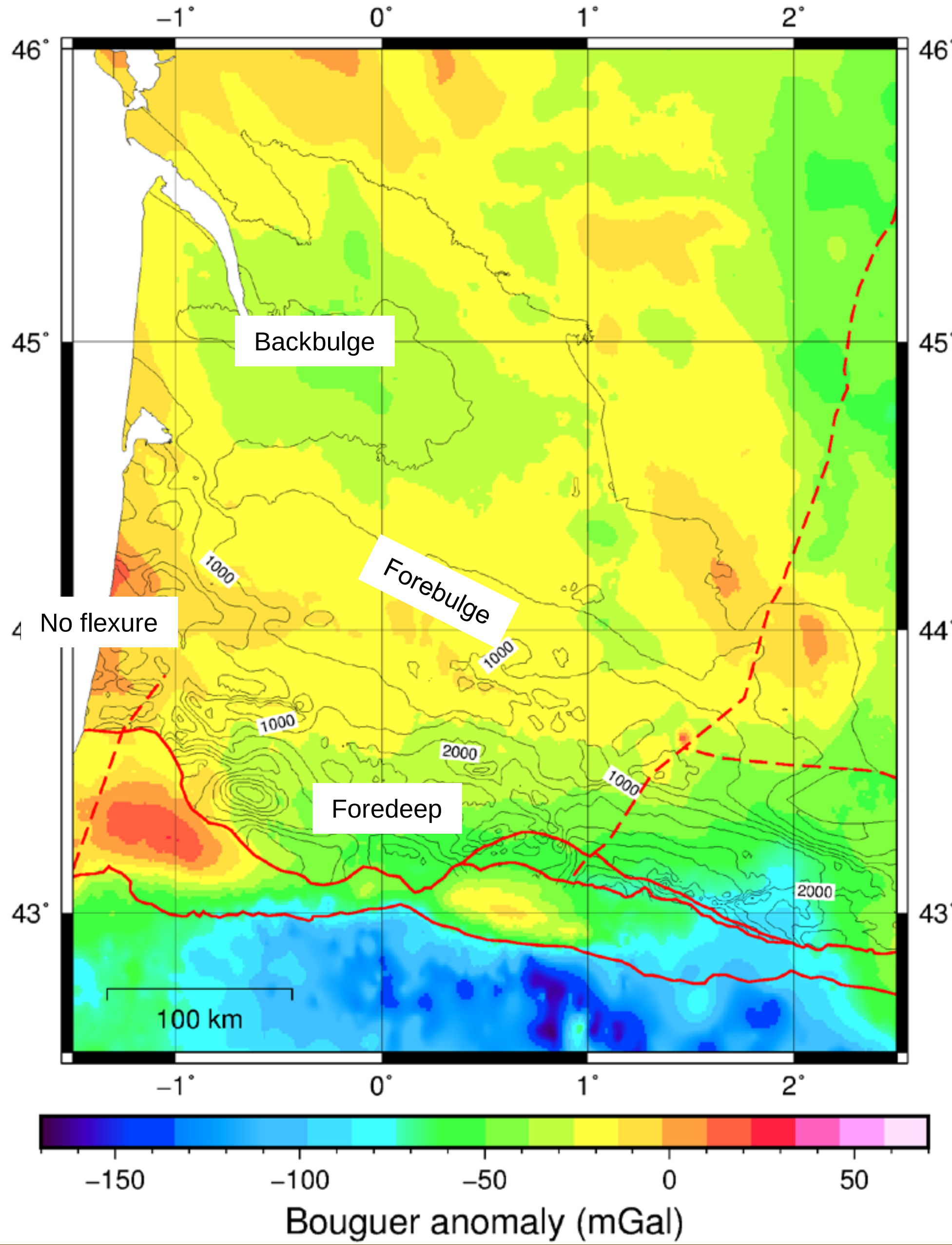


Thermal subsidence

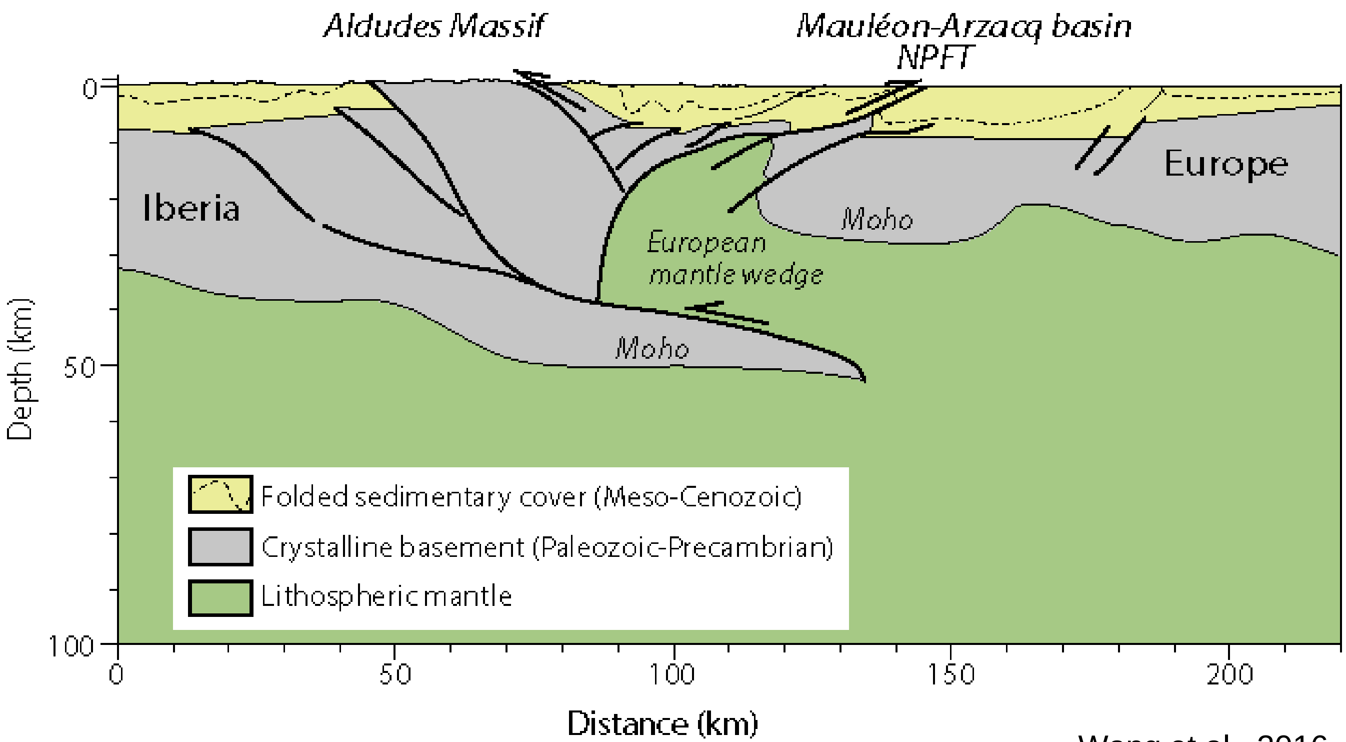


Courtesy of L. Guillou-Frottier

Gravity (Bouguer anomaly)

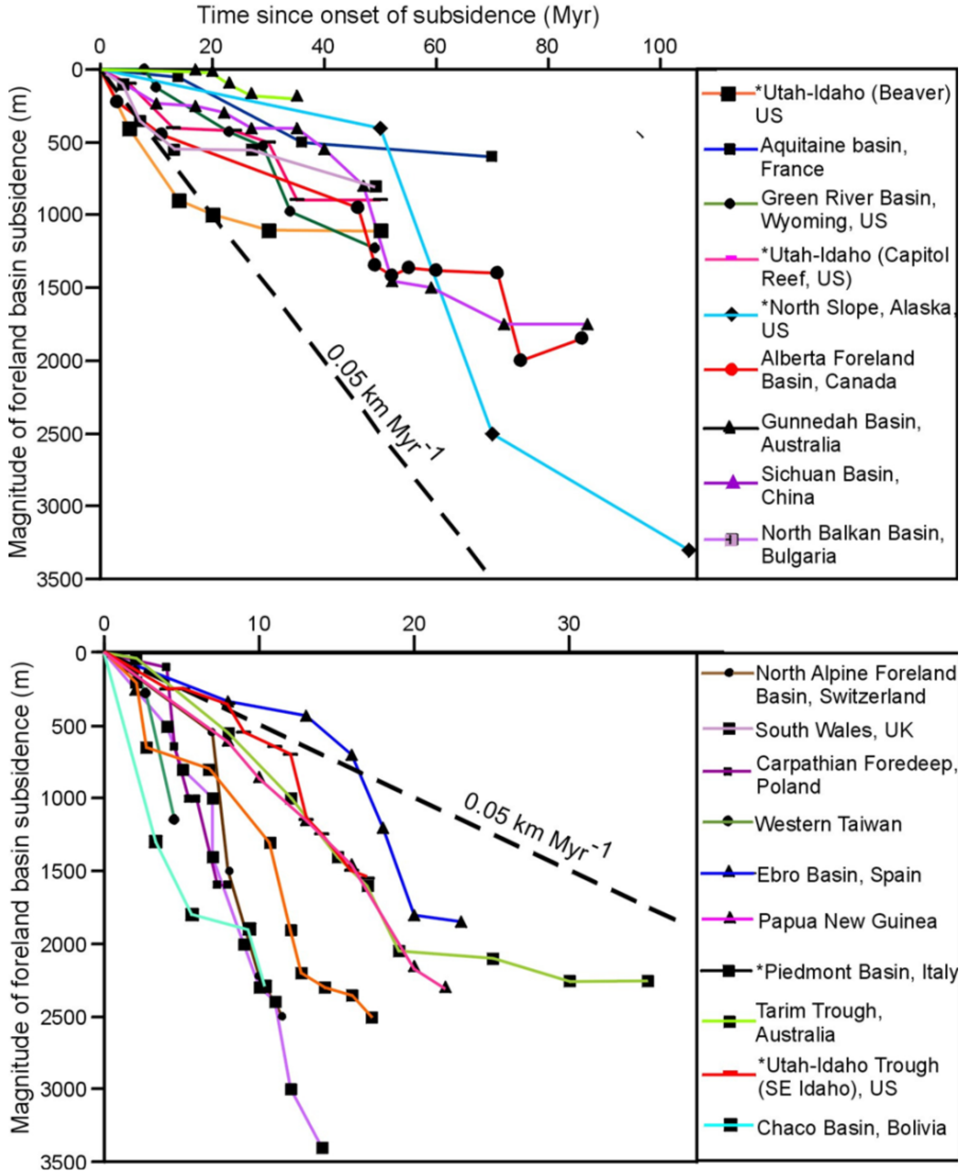


No flexure in the west?



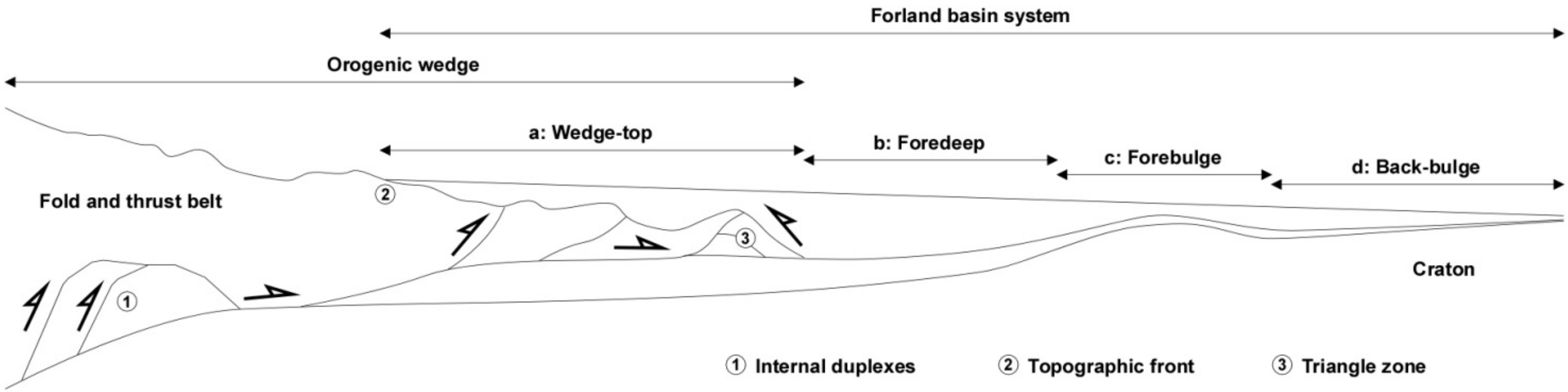
Wang et al., 2016

++ Subsidence in foreland basins



Naylor and Sinclair, 2008

Foreland basins



DeCelles and Giles, 1996

++ Gravity in foreland basin

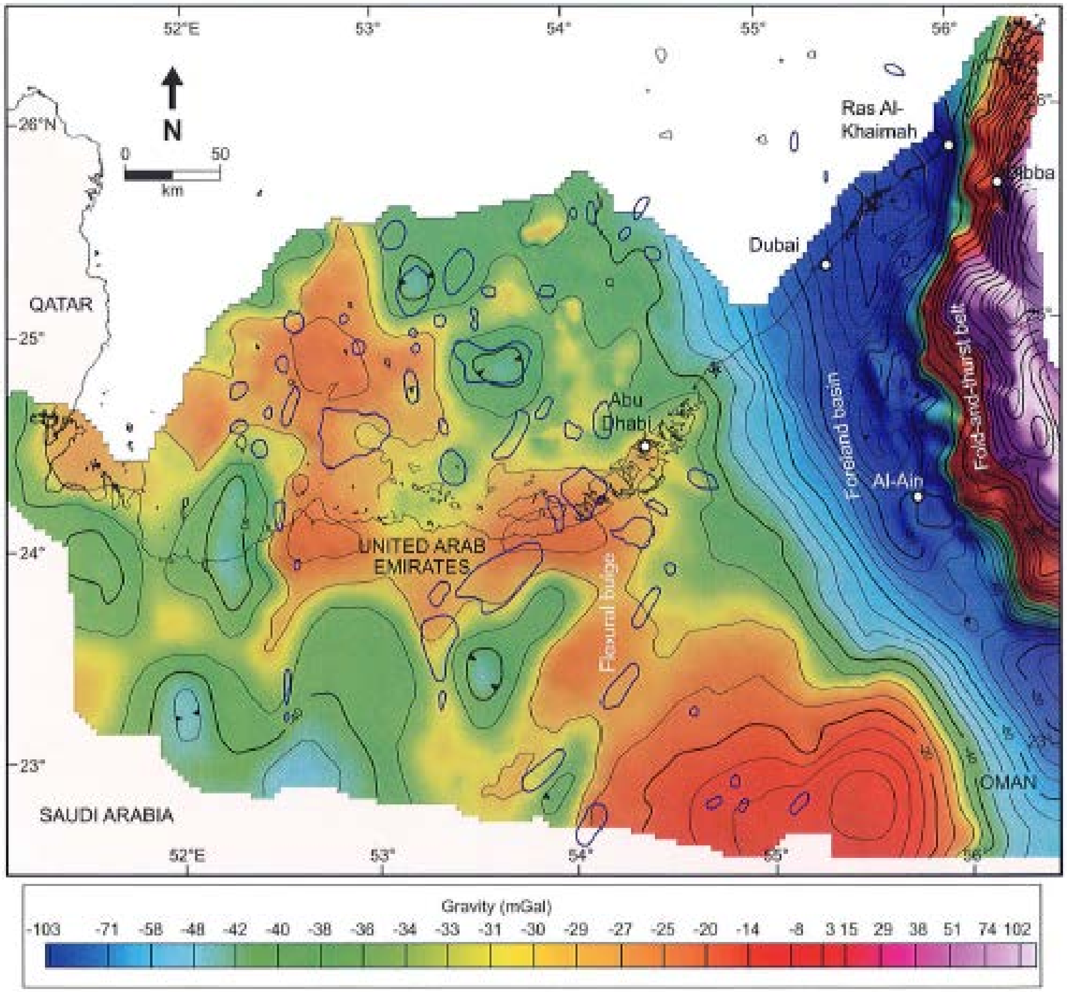
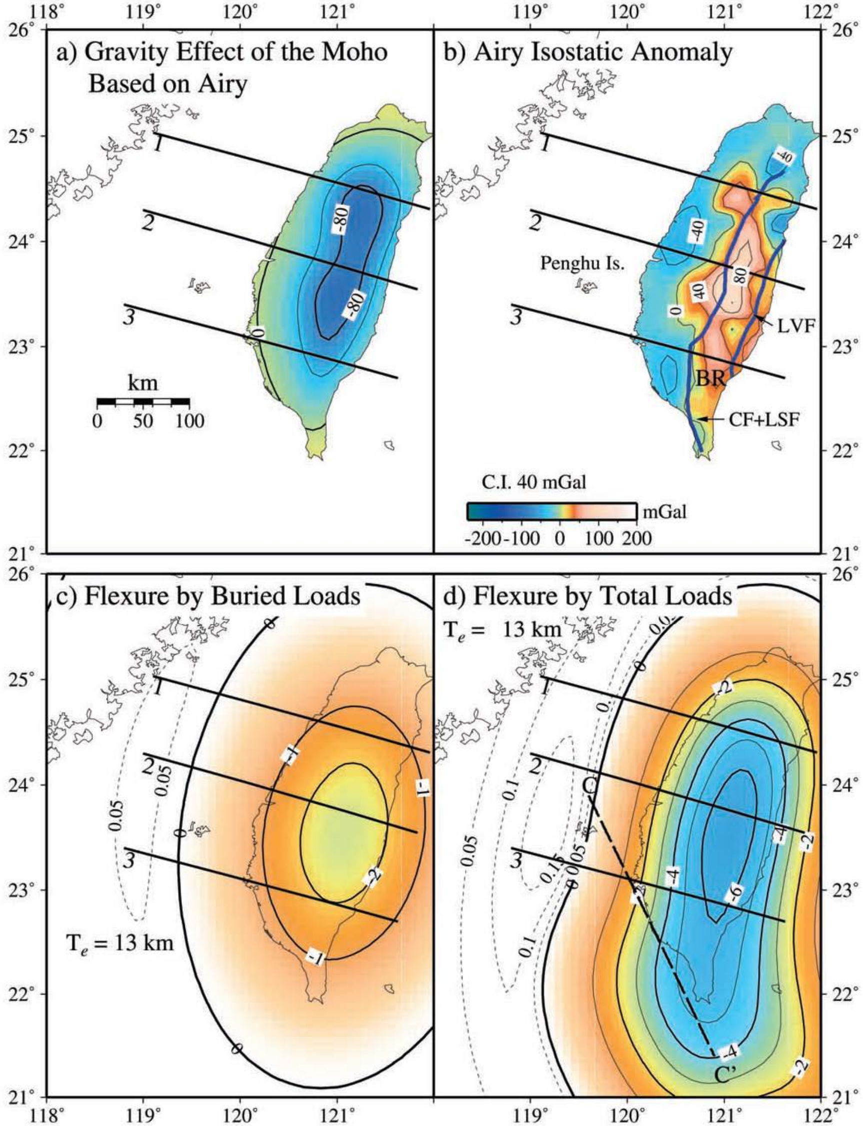


Figure 4: Bouguer anomaly map of the UAE and surrounding areas. Illumination from the northeast. The blue outlines show location of oil and gas fields. See Figure 2 for names of fields. See Enclosure I for enlarged version.

Ali et al., 2014



Lin and Watts, 2002