

Segmentation and structural style evolution during continental breakup:

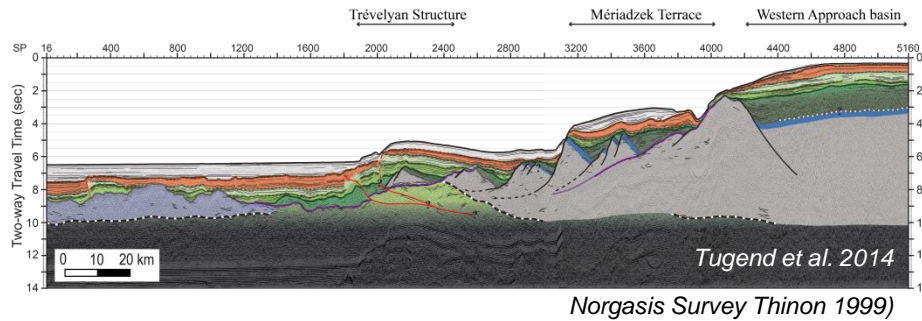
*observations from the Northern Bay of Biscay passive
margin (offshore France)*

J. Tugend, E. Masini, S. Leroy & L. Jolivet

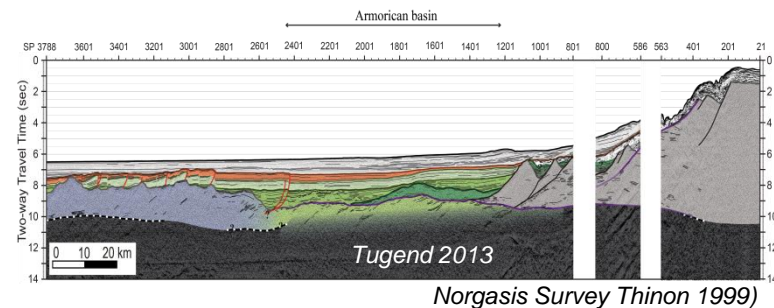


Northern Bay of Biscay segmentation

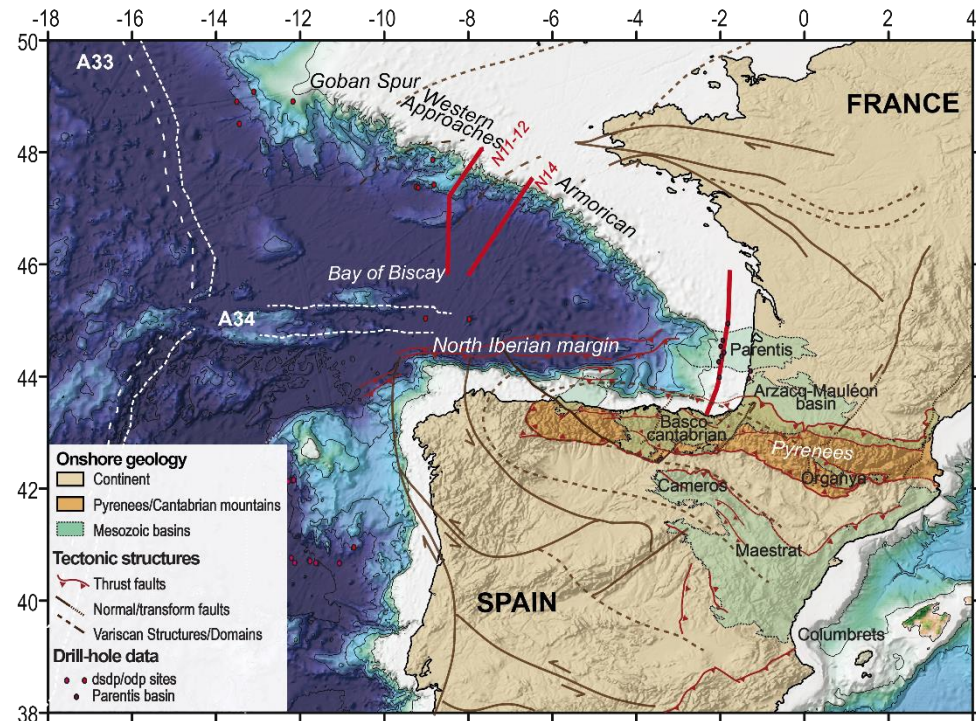
Western Approach margin



Armorican margin



Bay of Biscay

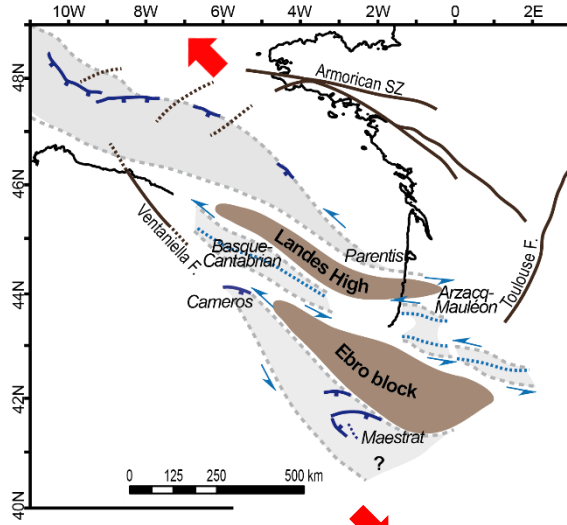


Significant morpho-structural changes are described along the Northern Bay of Biscay rifted margins (Thinon et al., 2003)

- Where and how does it occur?
- Origin of this change ?

Neogene	Holocene
	Pleistocene (Upper, Middle, Lower)
Neogene	Pliocene (Pliocene, Zanclean, Messinian)
	Miocene (Tortonian, Serravalian, Langhian, Burdigalian, Aquitanian)
Paleogene	Oligocene (Chattian, Rupelian, Priabonian, Bartonian)
	Eocene (Lutetian, Ypresian, Thanetian, Selandian, Danian)
Cretaceous	Upper (Maastrichtian, Campanian, Santonian, Coniacian, Turonian, Cenomanian)
	Lower (Albian, Aptian, Alamosan, Hauterivian, Valanginian, Berriasian)
Jurassic	Upper (Tithonian, Kimmeridgian, Oxfordian)
	Middle (Callovian, Bathonian, Bajocian, Aalenian)
Triassic	Lower (Toarcian, Pliensbachian, Sinemurian, Hettangian)
	Upper (Rhaetian, Norian, Carnian)
Permian	Middle (Ladinian, Anisian)
	Lower (Olenekian, Induan)
Permian	Lopingian, Wuchiapingian, Wuchapingian, Capitanian, Wordian, Roadian
	Cisuralian (Kungurian, Artinskian, Sakmarian, Asselian)

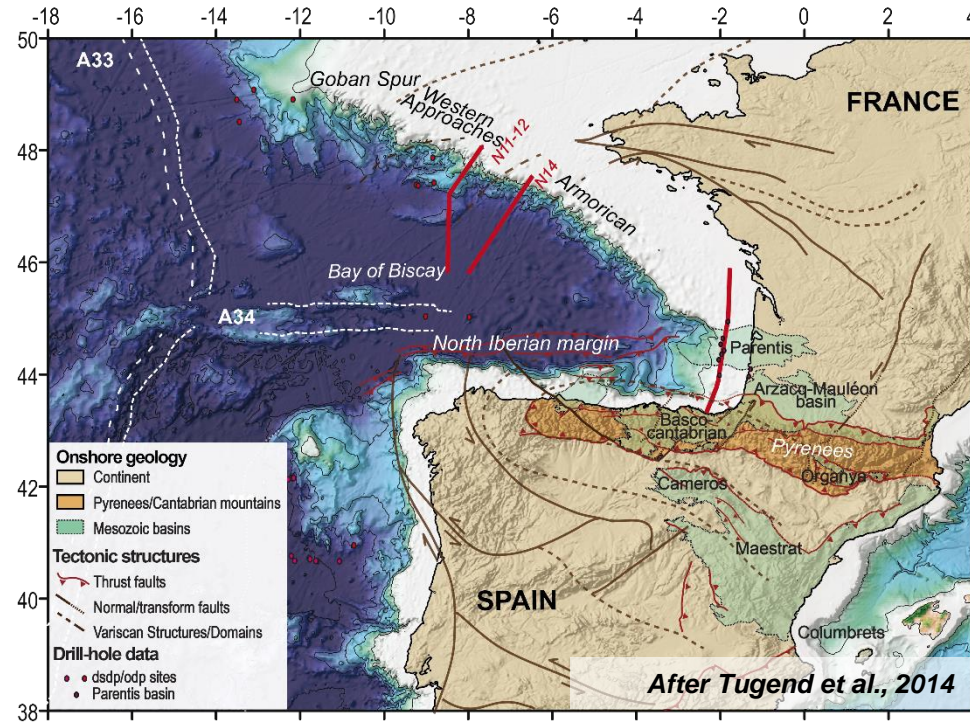
Oblique rifting (Latest Jurassic – Aptian)



Jurassique Sup.
(~145Ma)

Tugend et al., 2015b

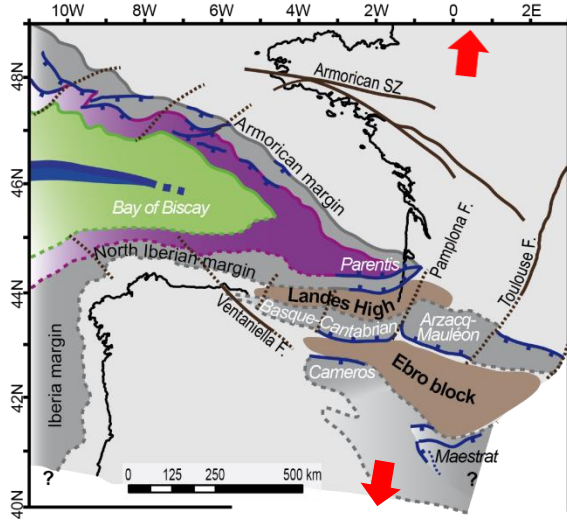
Bay of Biscay



What is the impact of oblique rifting on the structural style?

Neogene	Holocene		
	Pleistocene	Upper	
	Lower		
Neogene	Pliocene	Gelasian	
	Zanclean		
	Messinian		
	Tortonian		
	Serravalian		
Neogene	Miocene	Langhian	
	Burdigalian		
	Aquitanian		
	Oligocene	Chattian	
	Rupelian		
Paleogene	Eocene	Priabonian	
	Barthonian		
	Lutetian		
	Ypresian		
	Thanetian		
Paleogene	Paleocene	Selandian	
	Danian		
	Cretaceous	Upper	Maastrichtian
		Campanian	
		Santonian	
Coniacian			
Turonian			
Cretaceous	Lower	Cenomanian	
	Albian		
	Aptian		
	Barremian		
	Hauterivian		
Cretaceous	Valanginian		
	Berriasian		
	Tithonian		
	Upper	Kimmeridgian	
	Oxfordian		
Jurassic	Middle	Callovian	
	Bathonian		
	Bajocian		
	Aalenian		
	Toarcian		
Jurassic	Lower	Plensbachian	
	Sinemurian		
	Hettangian		
	Triassic	Upper	Rhaetian
		Norian	
Carnian			
Ladinian			
Anisian			
Triassic	Lower	Olenekian	
	Induan		
	Permian	Lopingian	
		Wuchiapingian	
		Capitanian	
Wordian			
Roadian			
Permian	Cisuralian	Kungurian	
	Artinskian		
	Sakmarian		
	Asselian		

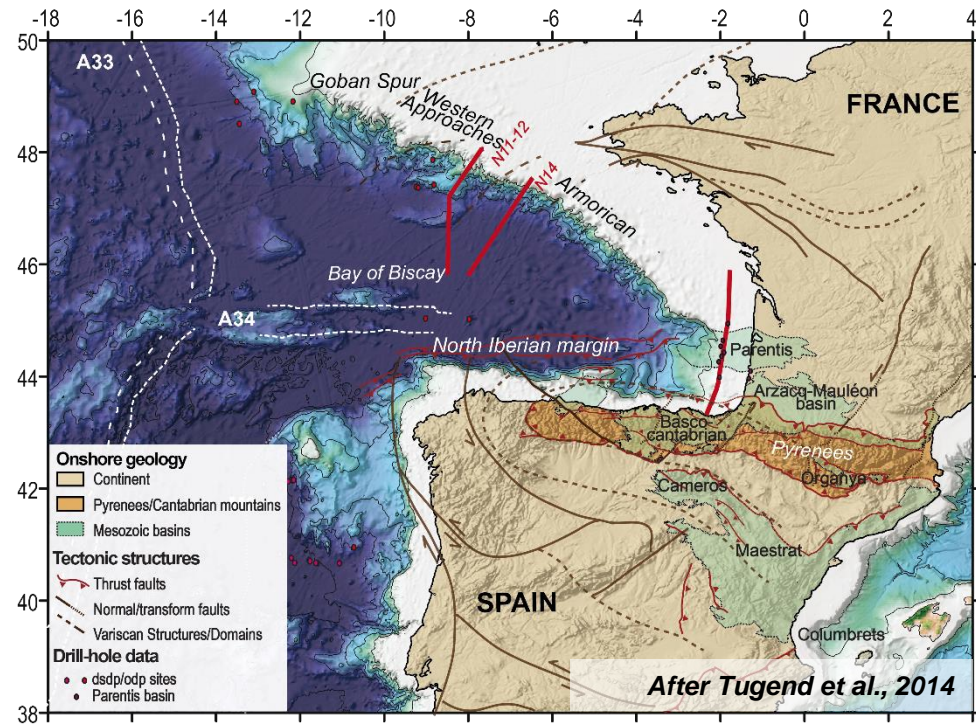
Onset of oceanic accretion



Aptien-Albien
(~110Ma)

Tugend et al., 2015b

Bay of Biscay

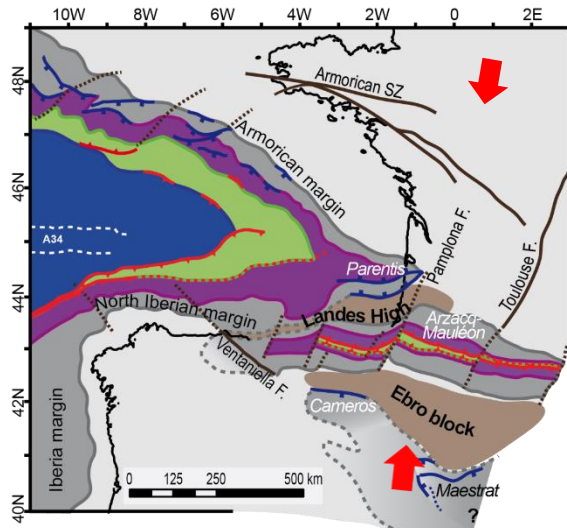


After Tugend et al., 2014

What is the structural style related to continental breakup?

Neogene	Holocene
	Pleistocene
	Pliocene
Miocene	Zanclean
	Messinian
	Tortonian
	Serravalian
	Langhian
	Burdigalian
	Aquitanian
Paleogene	Chattian
	Rupelian
	Prriabonian
	Barthonian
	Eocene
	Lutetian
	Ypresian
	Thanetian
	Selandian
	Danian
Cretaceous	Maastrichtian
	Campanian
	Santonian
	Coniacian
	Turonian
	Cenomanian
	Albian
	Aptian
	Barremian
	Hauterivian
Valanginian	
Jurassic	Berriasian
	Tithonian
	Upper Kimmeridgian
	Oxfordian
	Callovian
	Bathonian
	Lower Bajocian
Aalenian	
Triassic	Toarcian
	Plensbachian
	Sinemurian
	Hettangian
	Rhaetian
Permian	Upper Norian
	Carb. Carnian
	Middle Ladinian
	Anisian
	Lower Olenekian
Permian	Induan
	Changhsingian
	Lopingian
	Wuchapingian
	Guadalupian
	Wordian
	Roadian
	Kungurian
	Artinskian
	Sakmarian
Asselian	

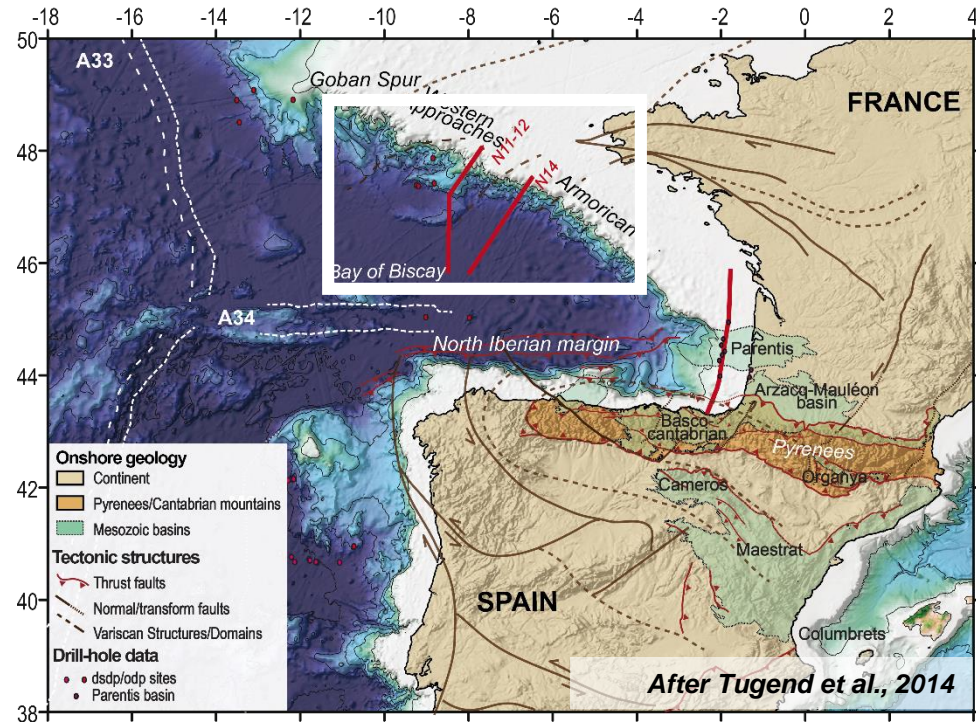
Pyrenean compression



Crétacé Sup.
(~80Ma)

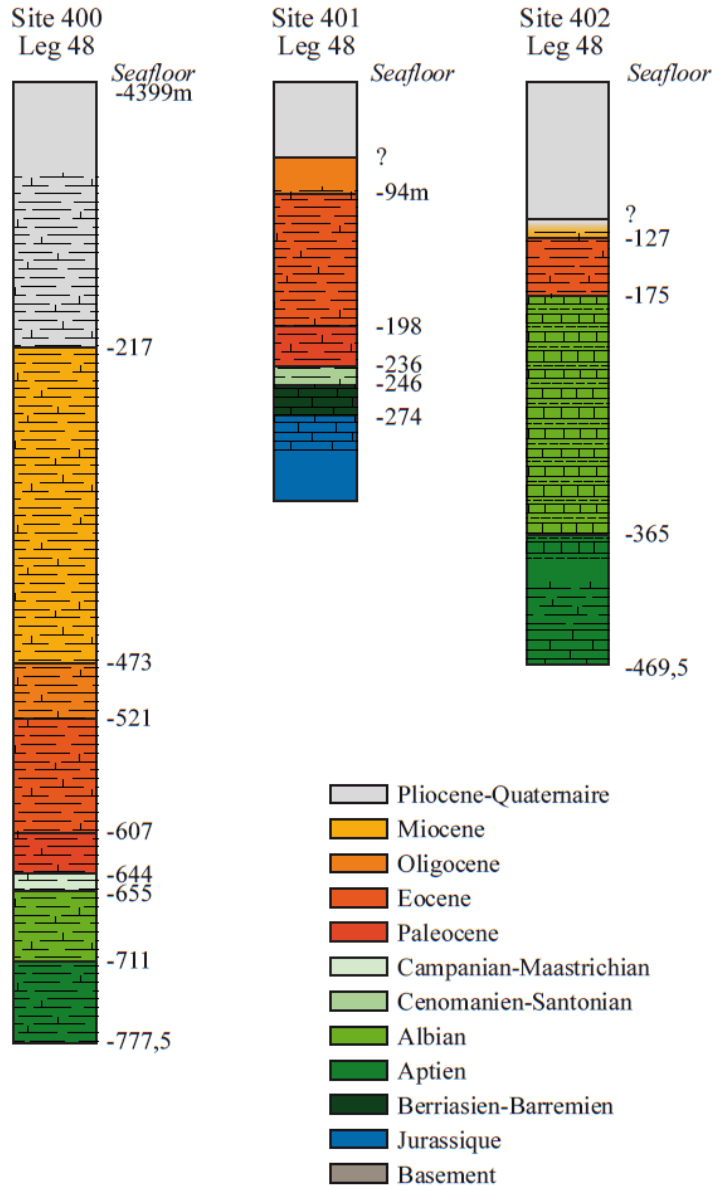
Tugend et al., 2015b

Bay of Biscay

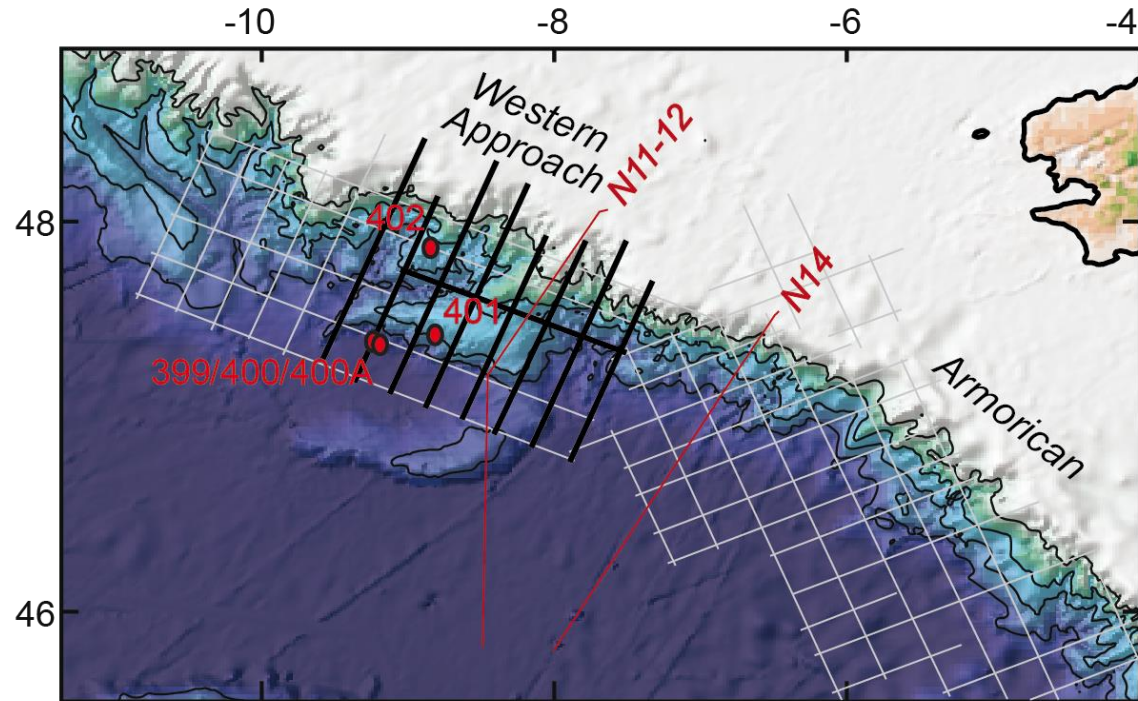


After Tugend et al., 2014

DSDP drilling results

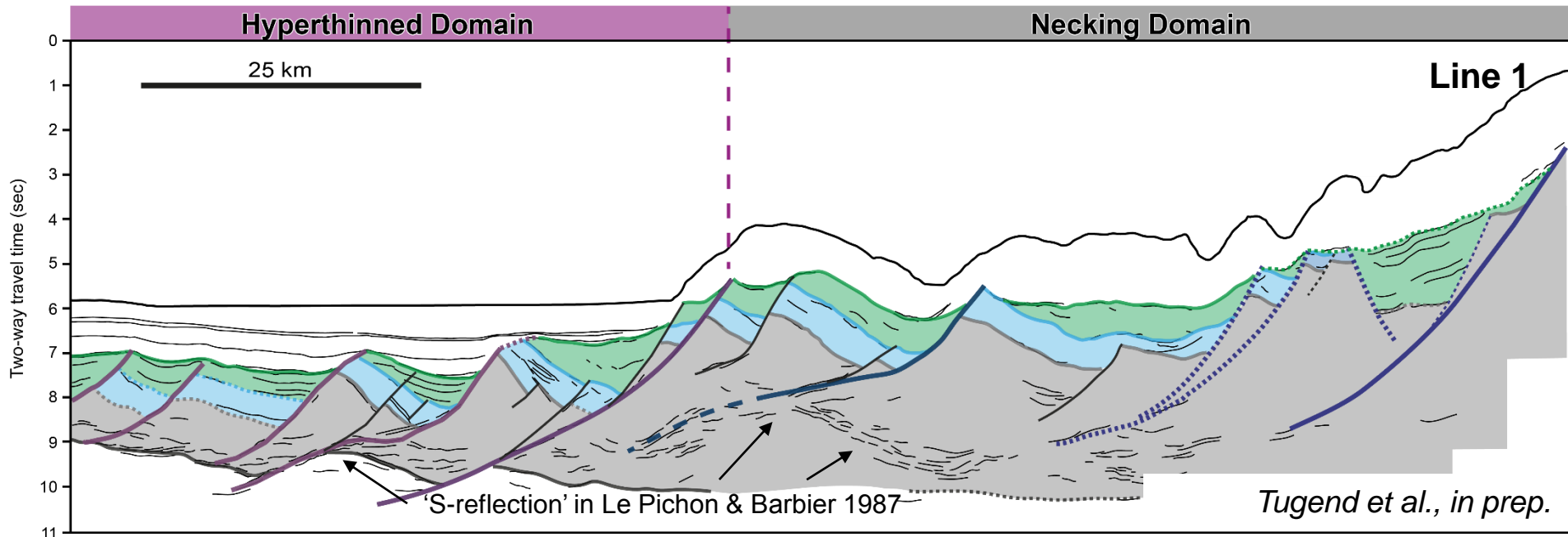
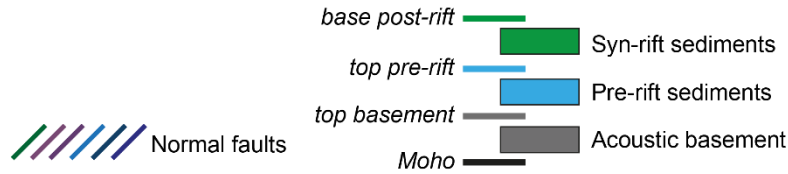
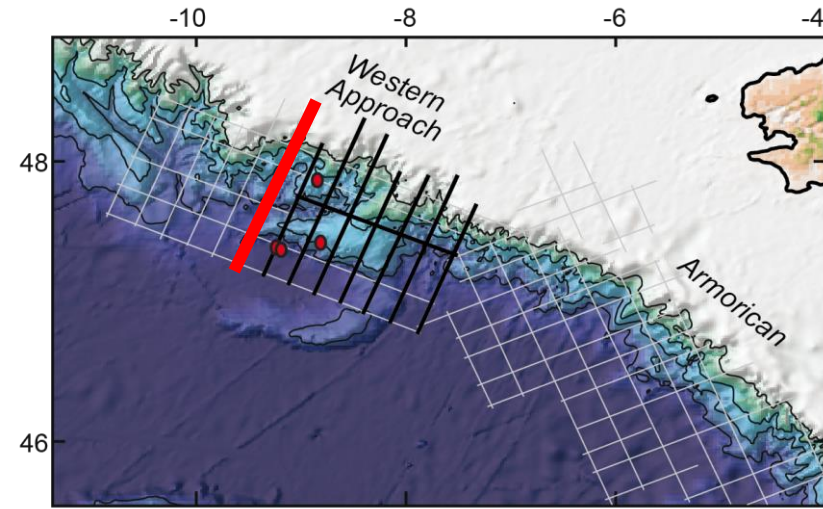


Series of reflection seismic sections

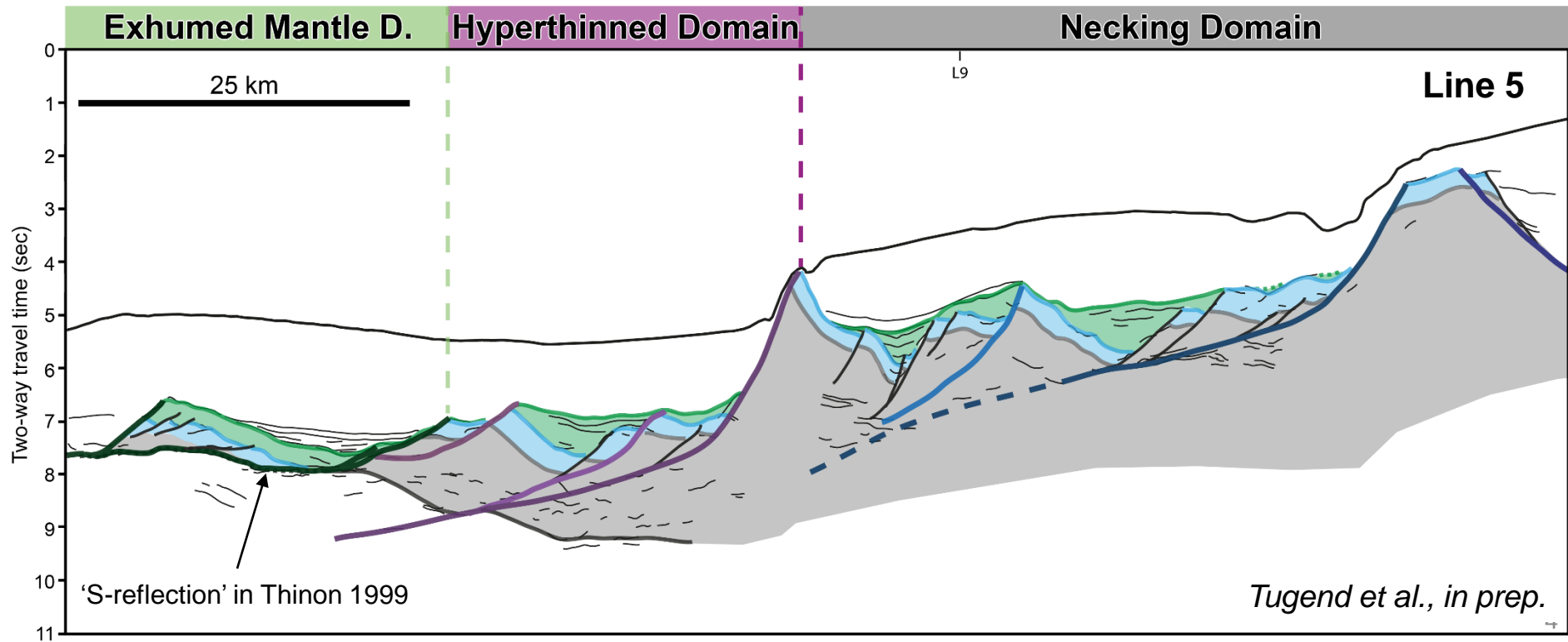
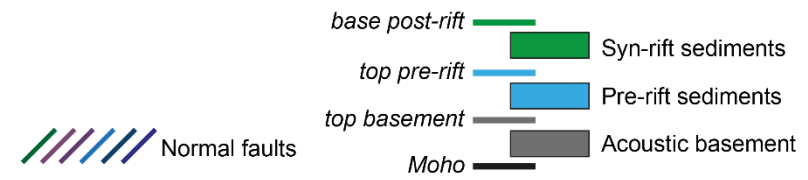
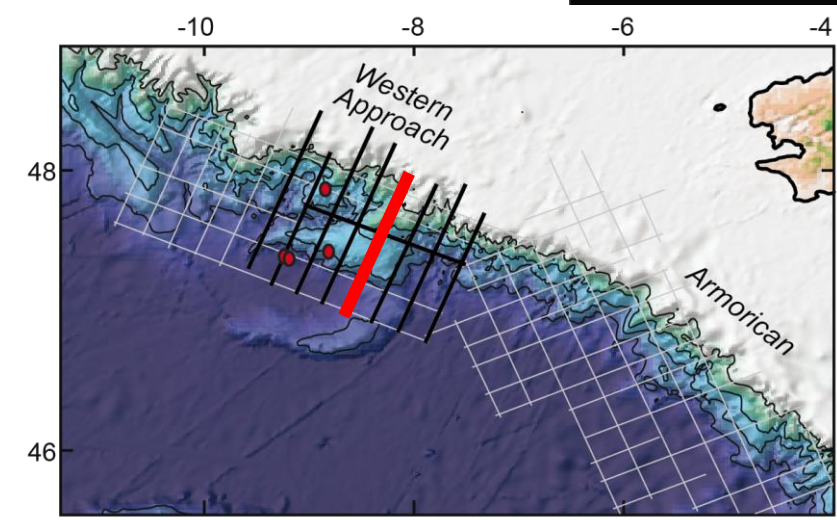


Previous works by Guennoc 1978; Barbier 1986; Deregnacourt 1981; Thinon 1999

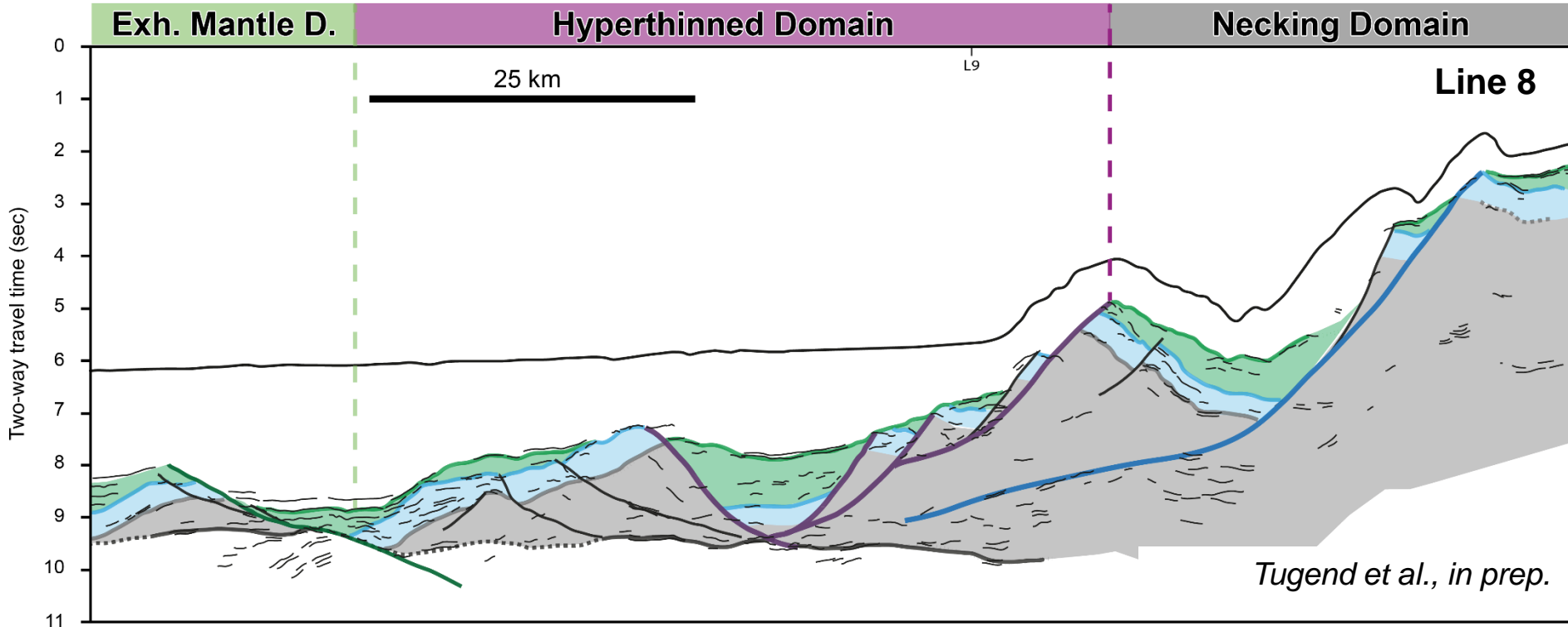
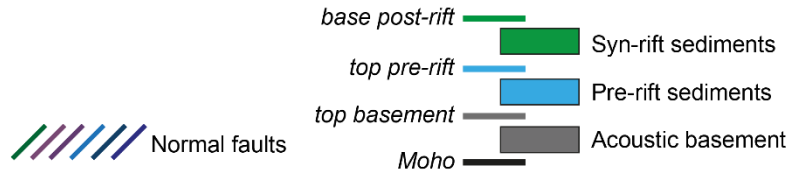
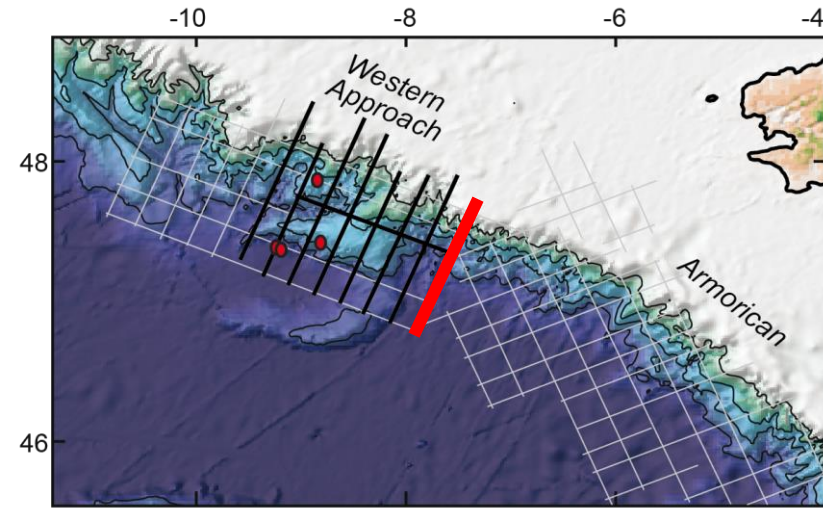
- Necking domain: faults root on an intra-basement decoupling interface (*top lower crust?*).
 - Hyperthinned domain: fault root at the Moho or deeper.
- **Evolution of the nature and depth of the fault rooting level**



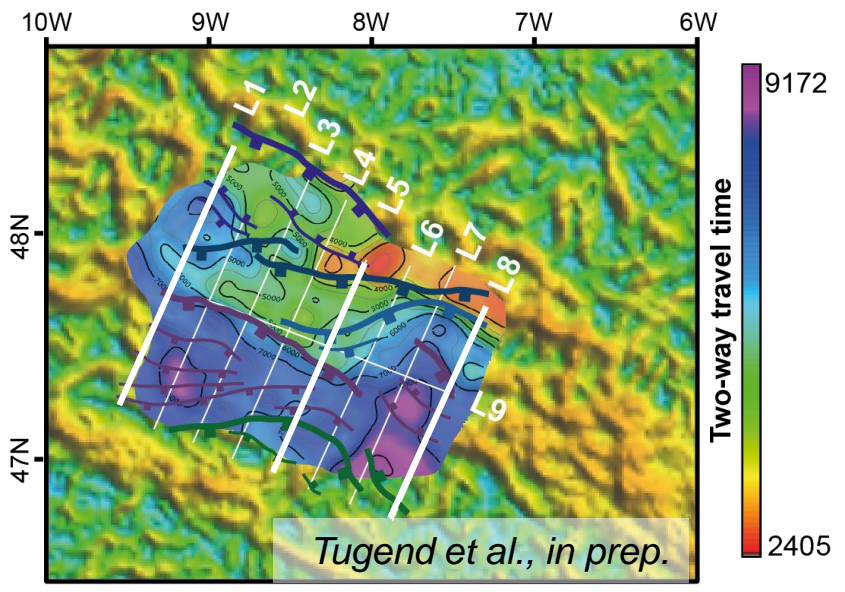
- Mantle seems to be exhumed locally forming the ocean-continent-transition (*Thinon et al., 2003, Tugend et al., 2014*)



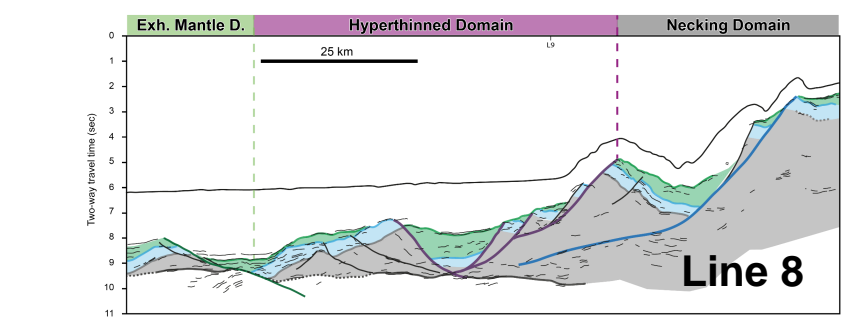
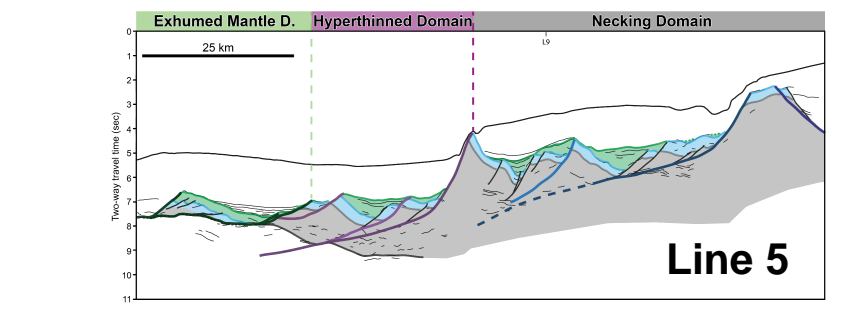
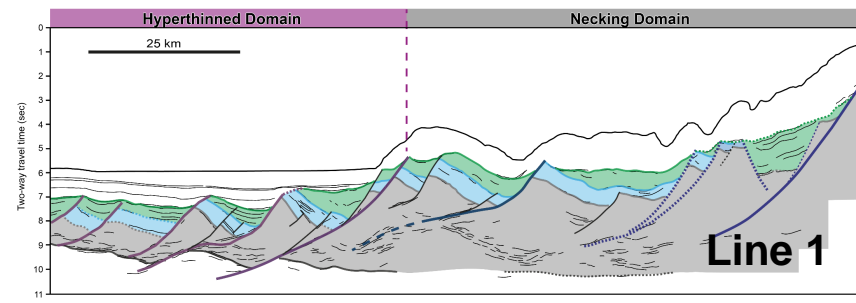
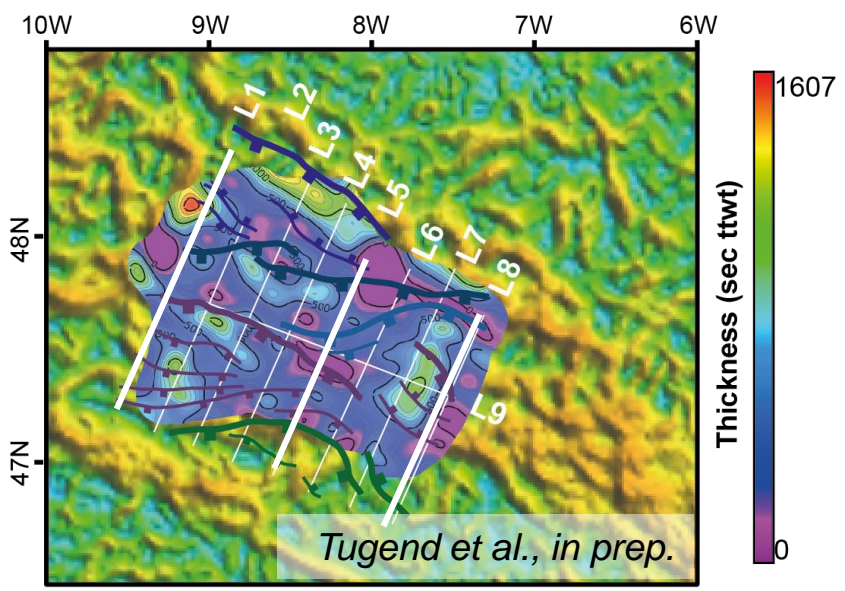
- A change in structural style occurs in the distal margin. Normal faults dip mainly continentward.



Isobath top pre-rift

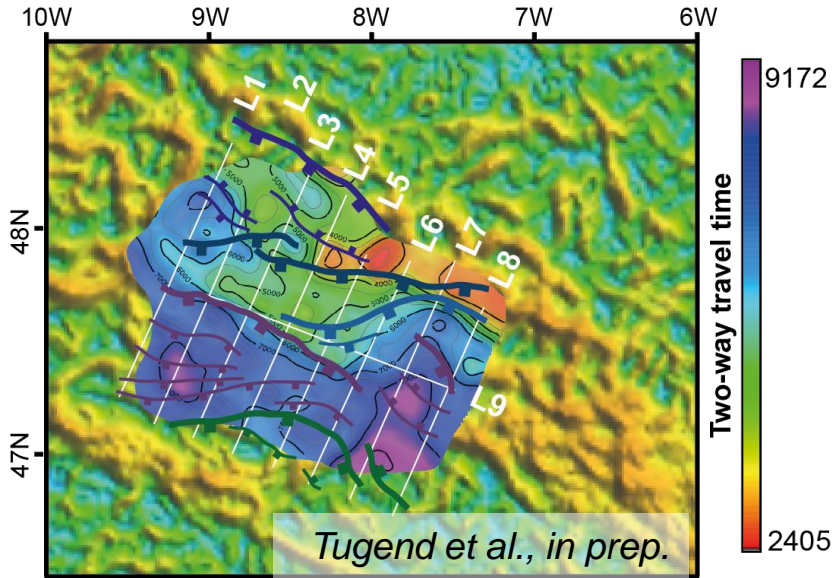


Isochore syn-rift sediments

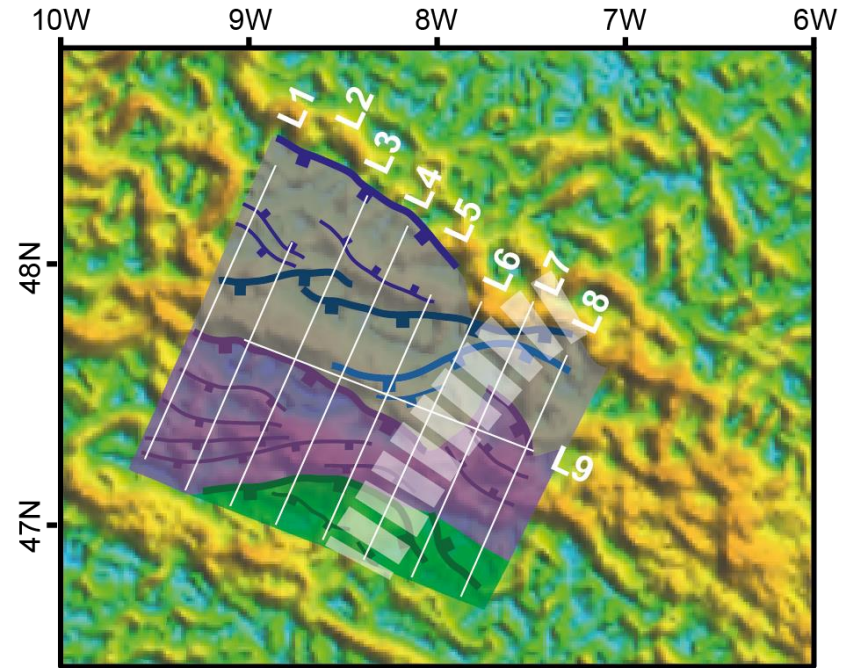


- **Loose segment transition**
- Progressive change in structural style in the distal margin (*hyperthinned domain*) and OCT (*Exhumed mantle domain*).

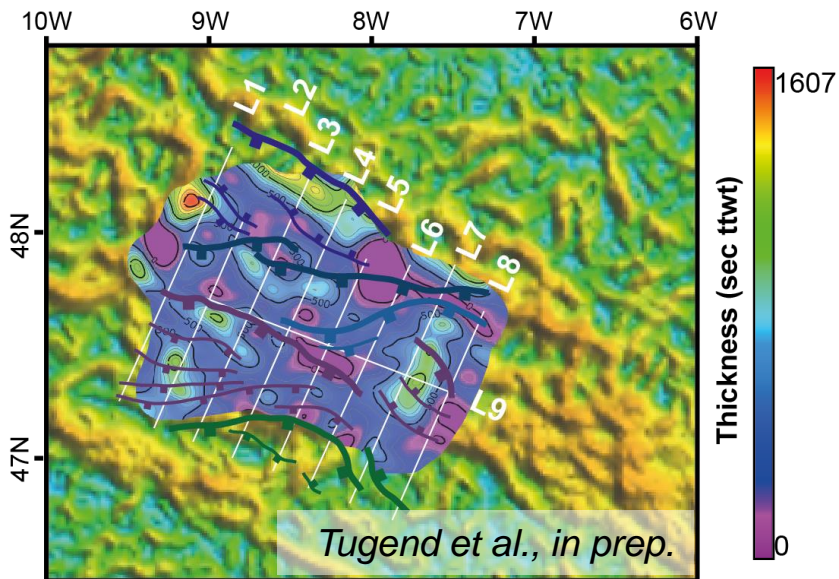
Isobath top pre-rift



Rift domain map



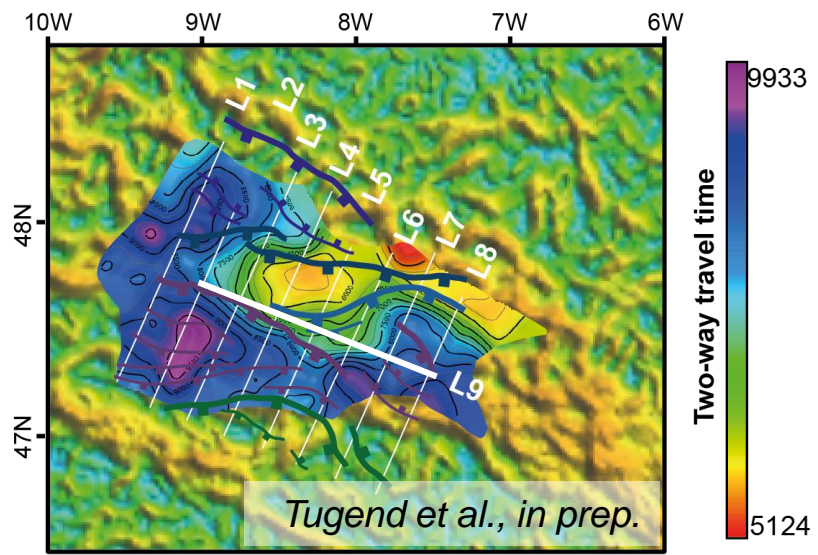
Isochore syn-rift sediments



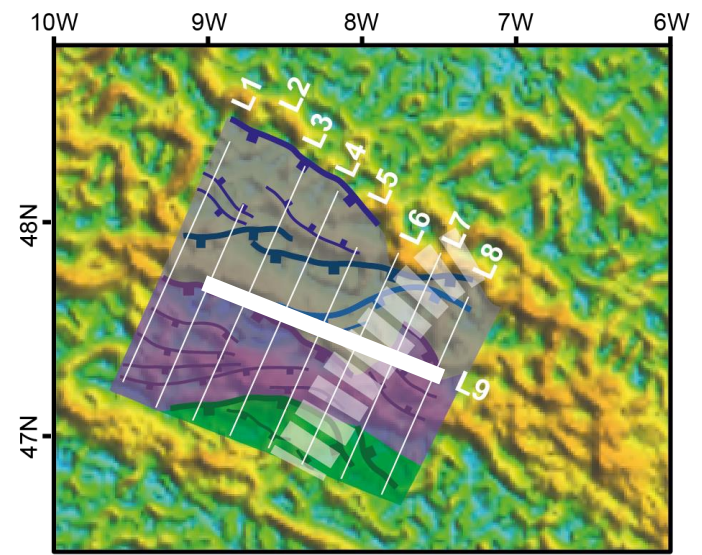
- Progressive change in structural style likely to be related a different accommodation of extensional deformation across the transfer zone.

How is accommodated this segment transition?

Isobath of the fault rooting level

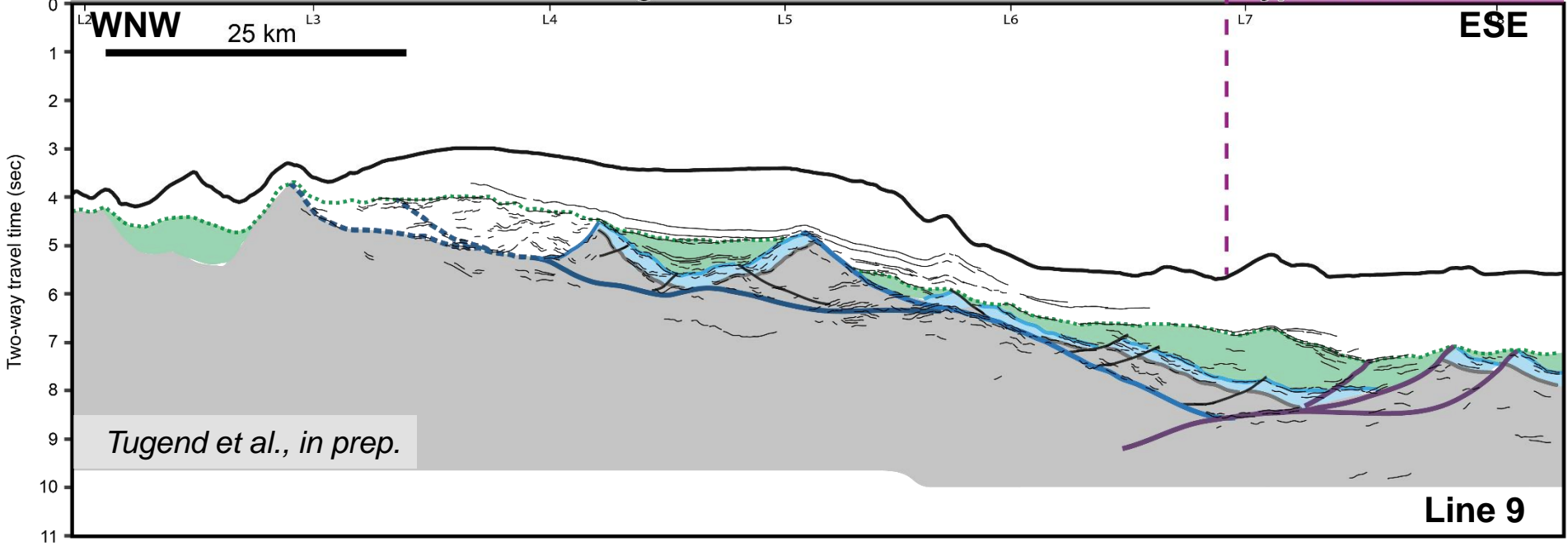


Rift domain map

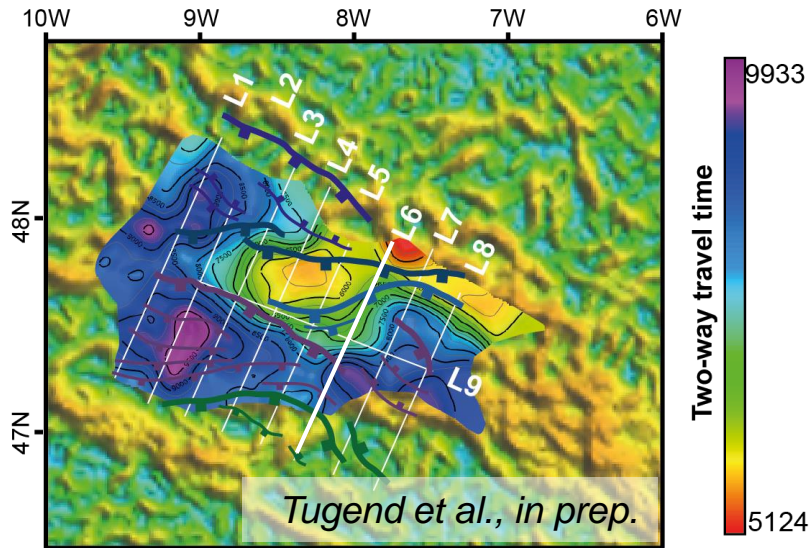


Necking Domain

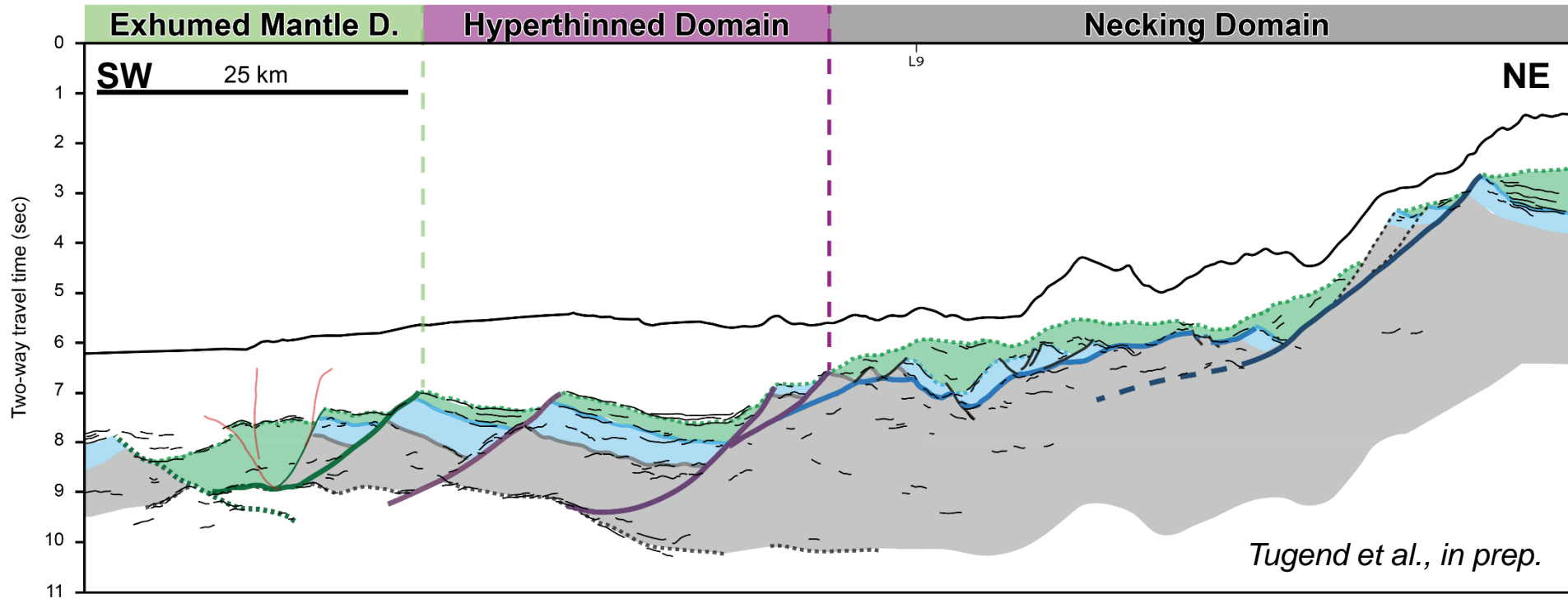
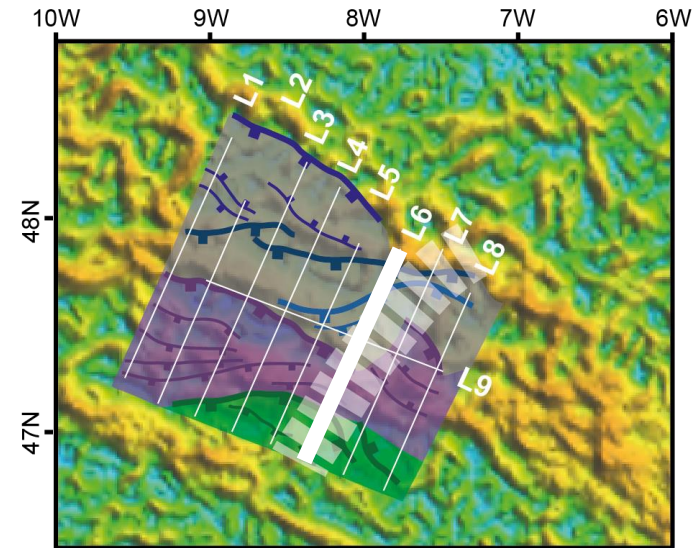
Hyperthinned Domain

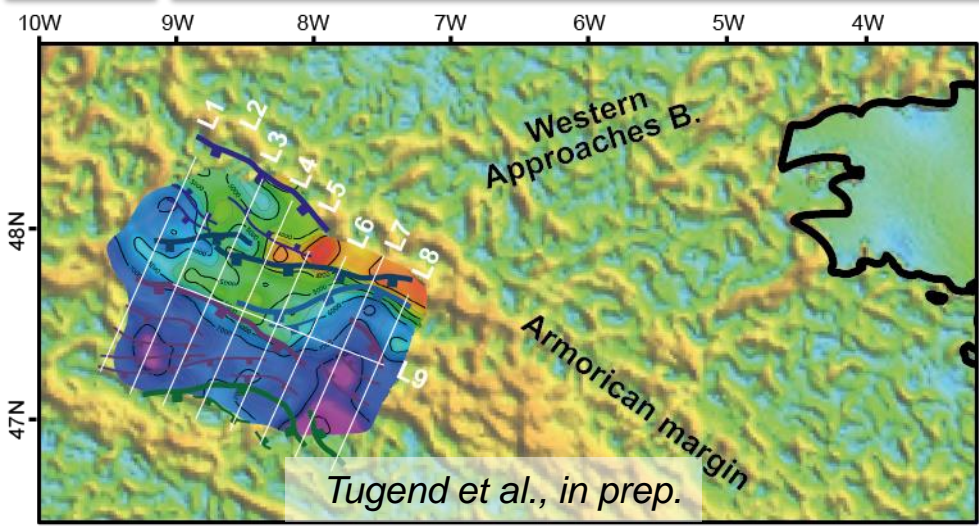


Isobath of the fault rooting level

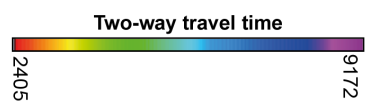


Rift domain map

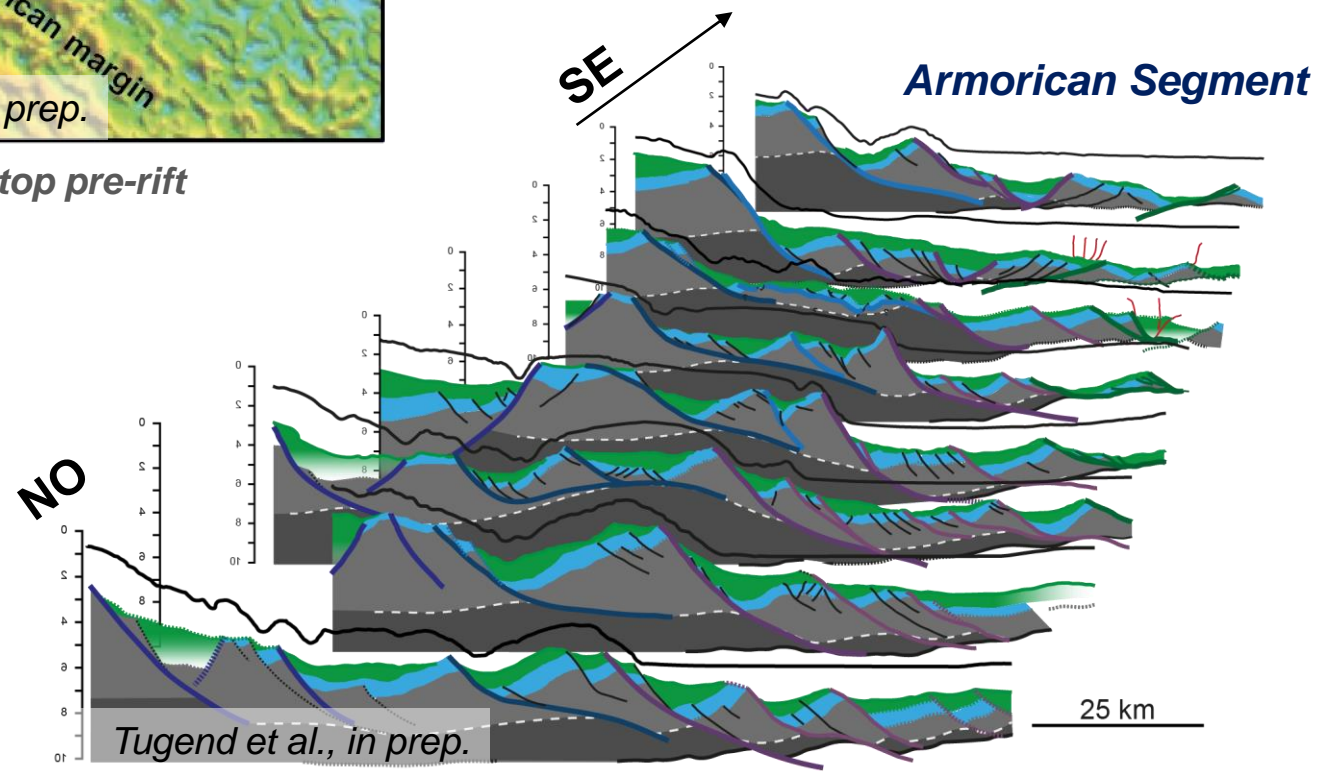




1. Morpho-structural variations across a loose transfer zone.



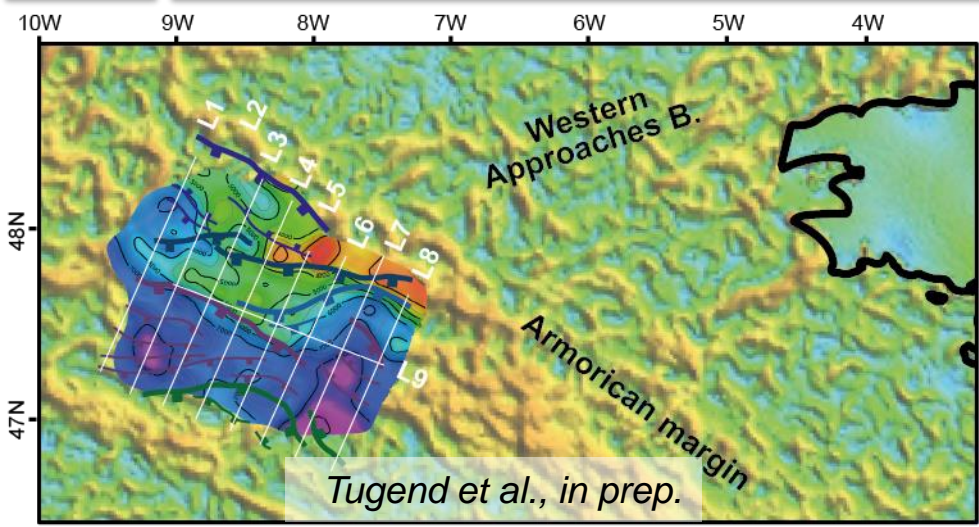
Isobath top pre-rift



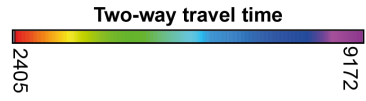
Continent

Western Approach Segment

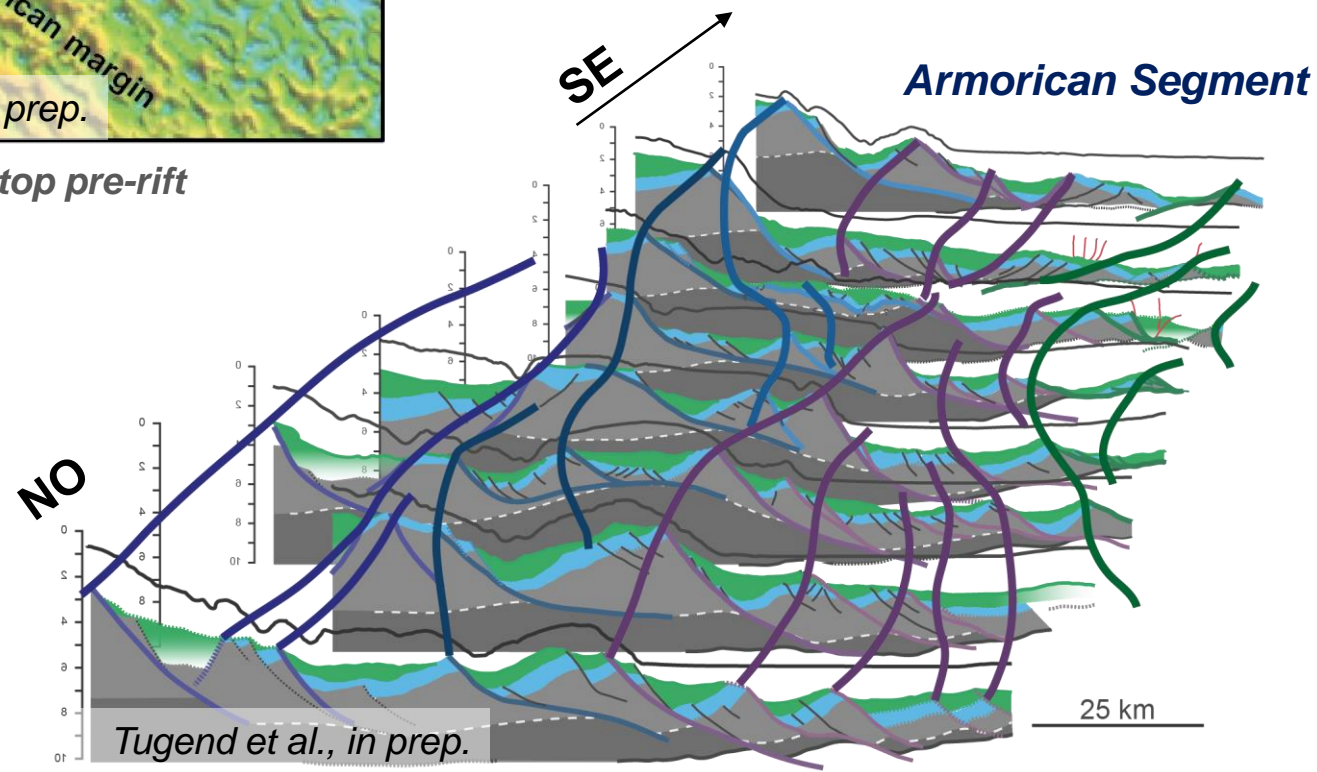
Ocean →



1. Morpho-structural variations across a loose transfer zone.
2. Horse-tail structures



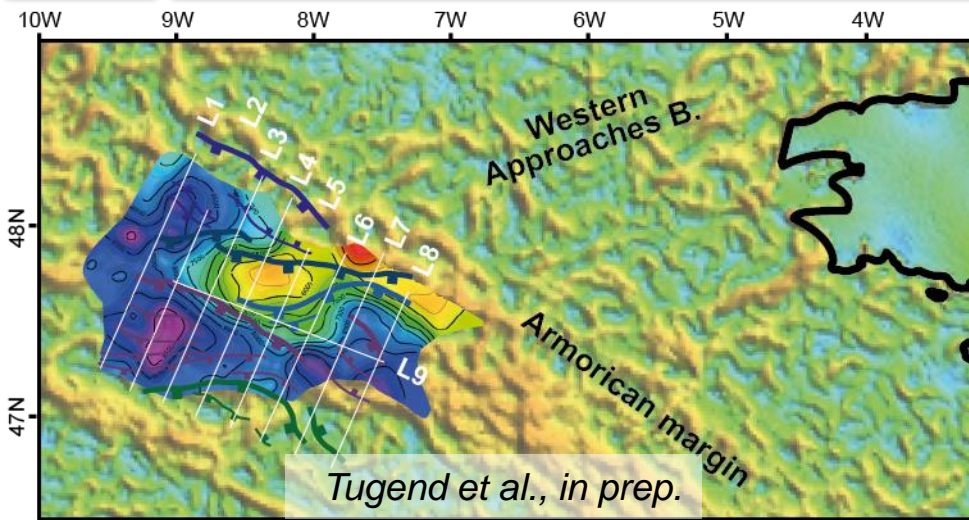
Isobath top pre-rift



Continent

Western Approach Segment

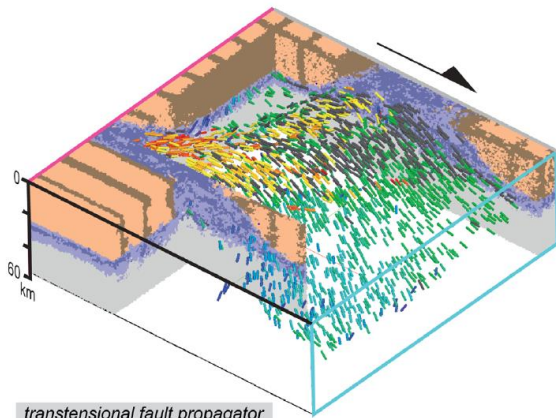
Ocean



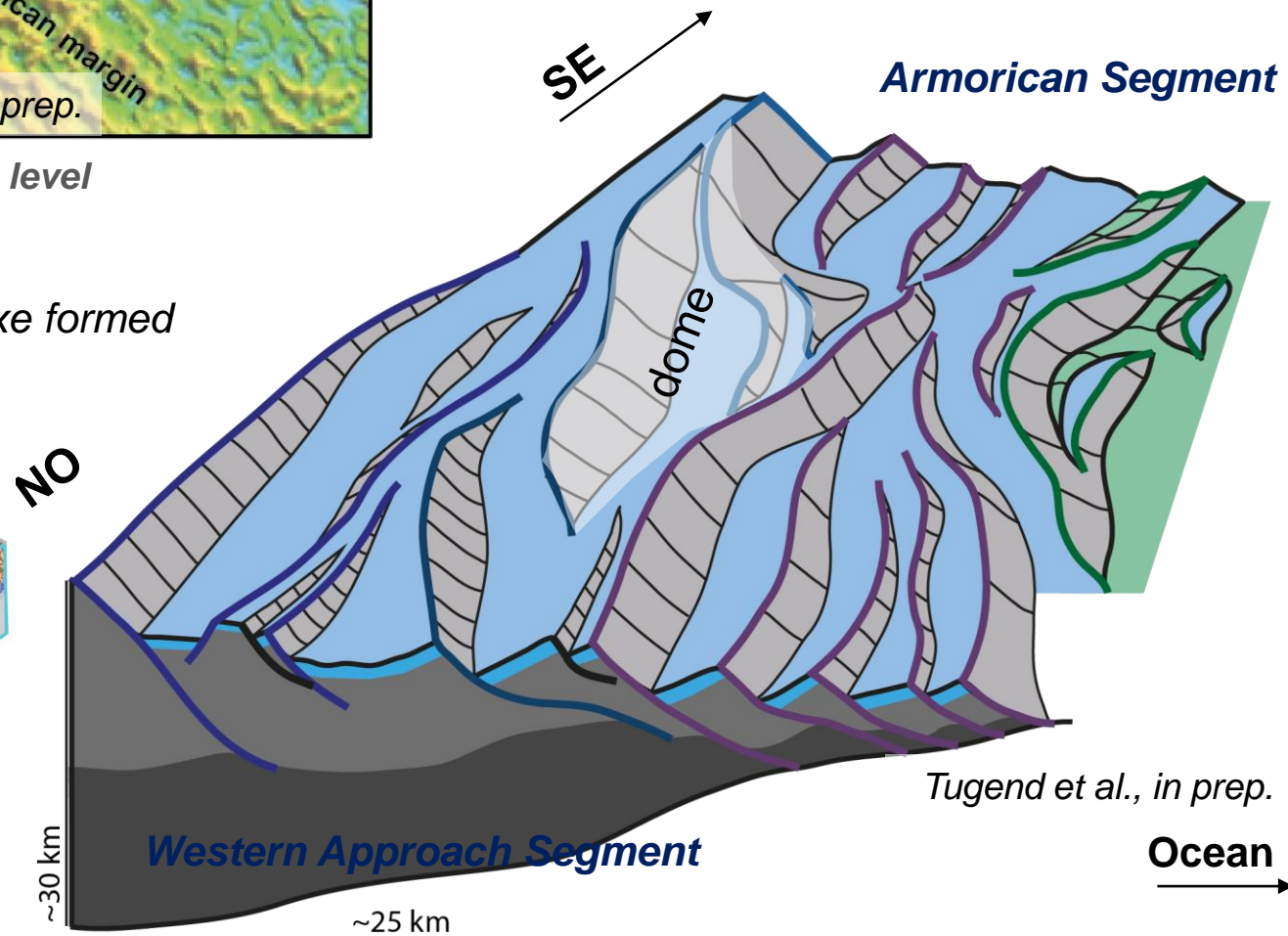
1. Morpho-structural variations across a loose transfer zone.
2. Horse-tail structures rooting on a lower crustal dome

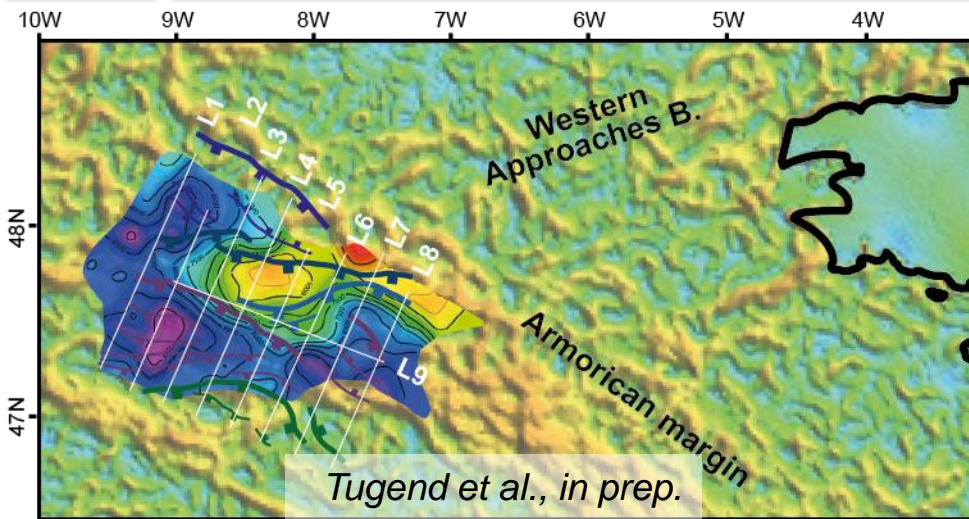


► Analogue to core-complexes formed in transtension?



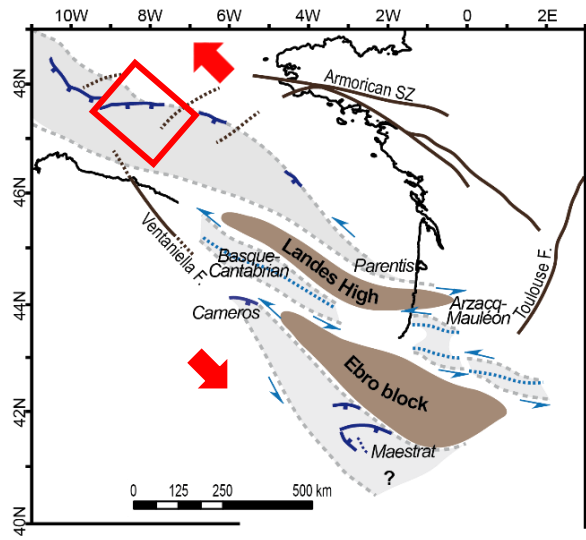
Le Pourhiet et al., 2012



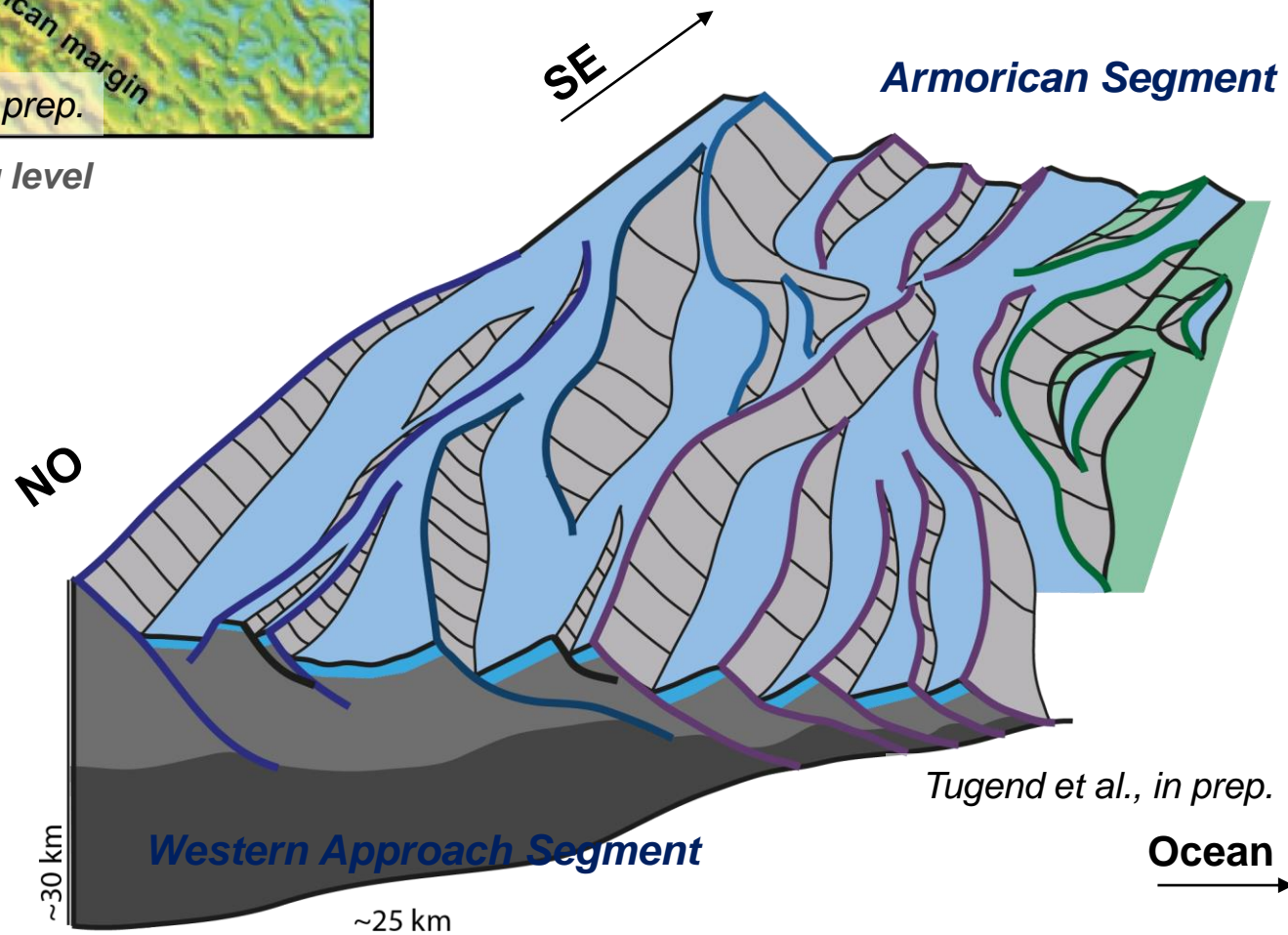


1. Morpho-structural variations across a loose transfer zone.
2. Horse-tail structures rooting on a lower crustal dome (impact of oblique rifting?)

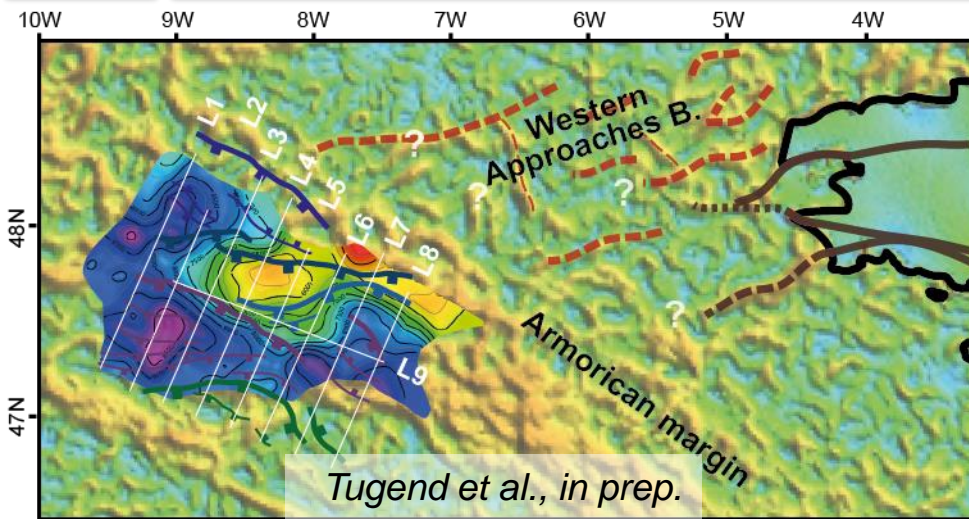
Two-way travel time
5124 9933
Fault rooting level



Tugend et al., 2015b
Oblique rifting
(Latest Jurassic – Aptian)



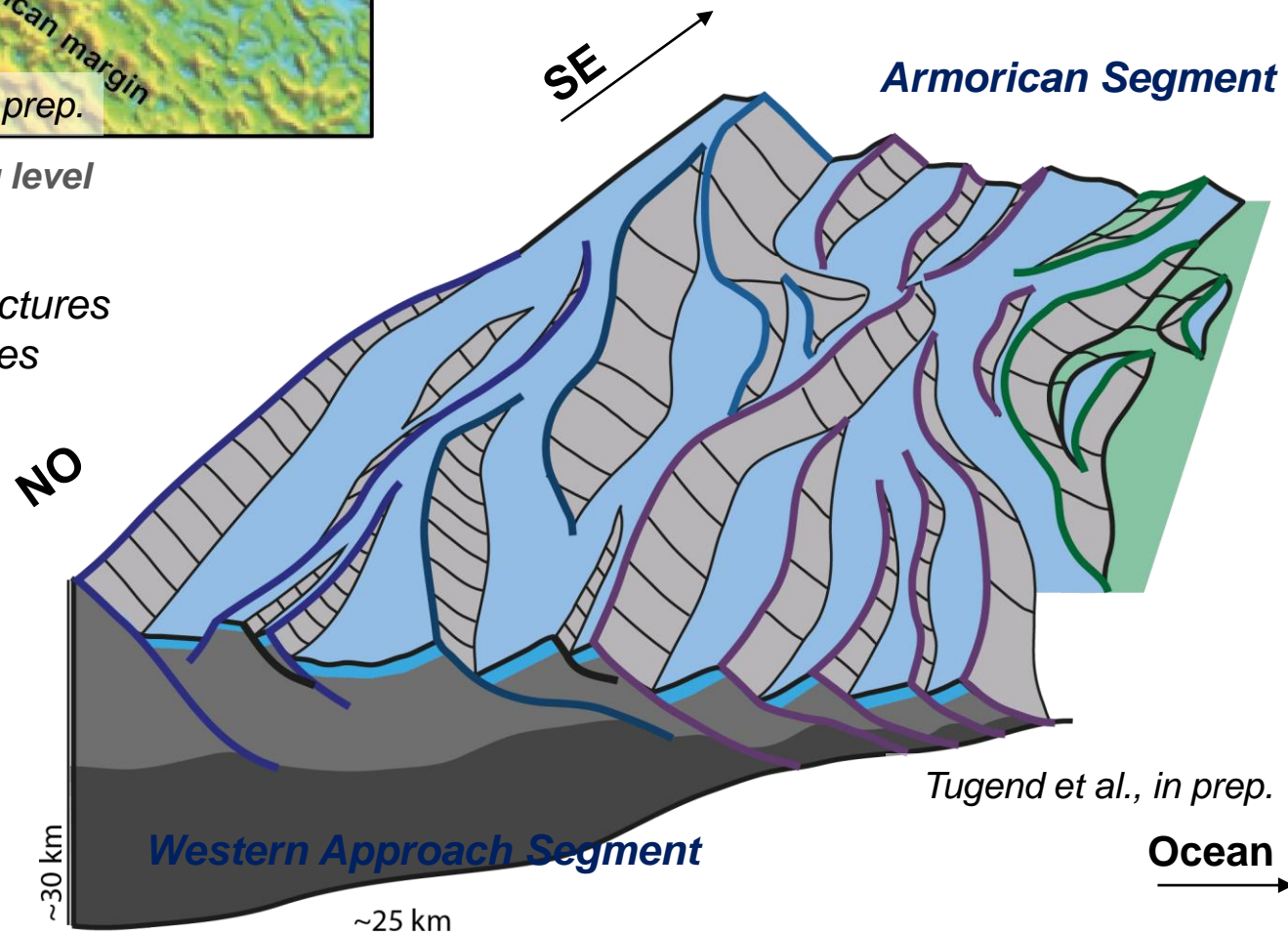
Tugend et al., in prep.
Western Approach Segment
Armorican Segment
Ocean



1. Morpho-structural variations across a loose transfer zone.
2. Horse-tail structures rooting on a lower crustal dome (impact of oblique rifting?)
3. Role of structural inheritance?

Two-way travel time
5124 9933
Fault rooting level

- *Permo-Carboniferous structures versus Western Approaches B. structures*



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