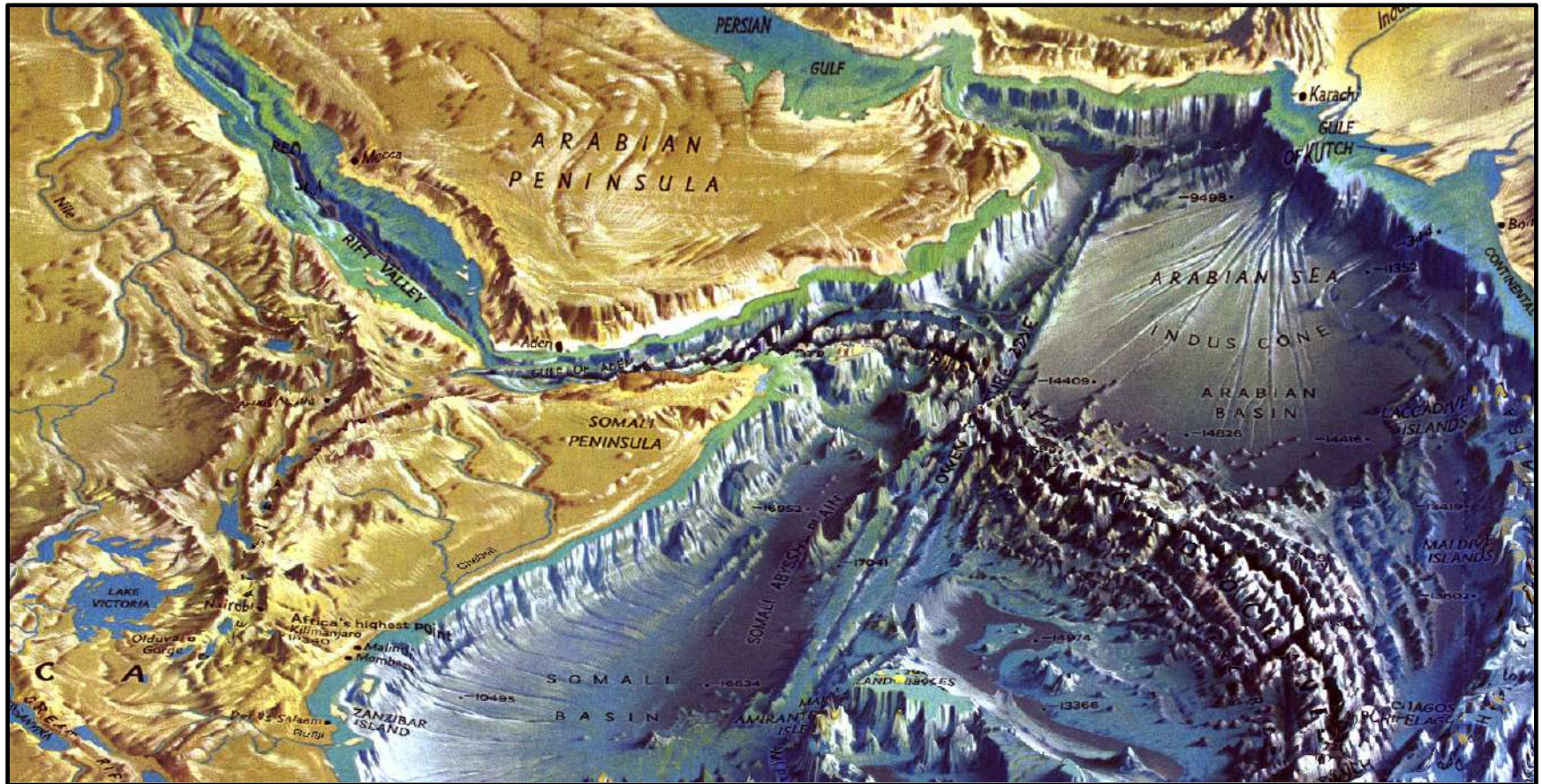



# Facteurs de contrôle sur la sédimentation gravitaire profonde



Sébastien Zaragosi  
Université de Bordeaux  
<http://www.geocean.net>

université  
de **BORDEAUX**

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# S1ST925T - SEDIMENTATION DES MILIEUX MARINS PROFONDS

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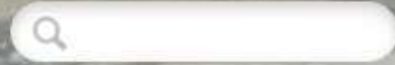
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Bac 2 Géologie  
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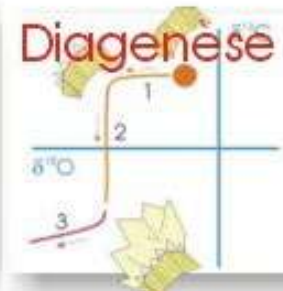
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Bac 3 Géologie

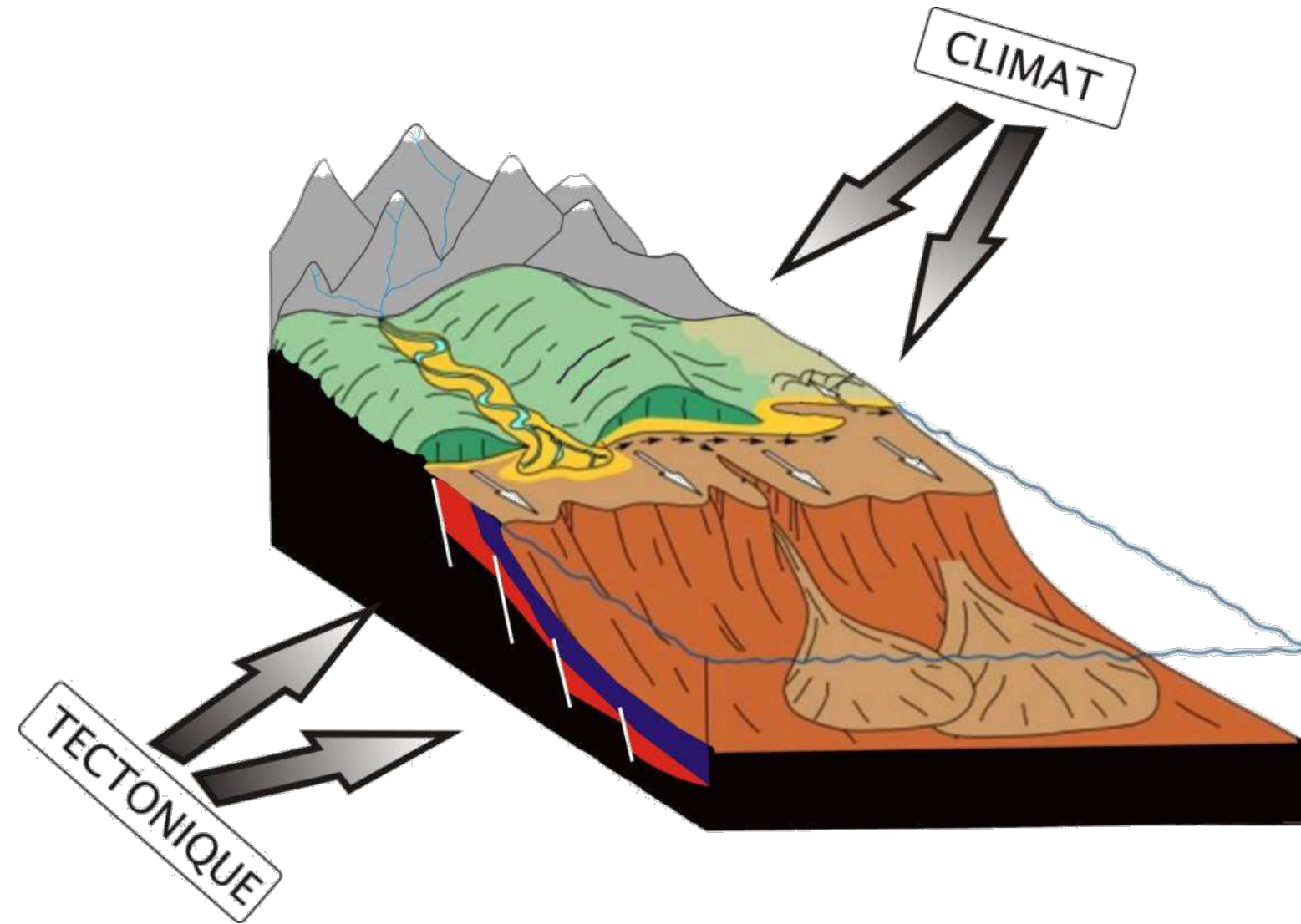


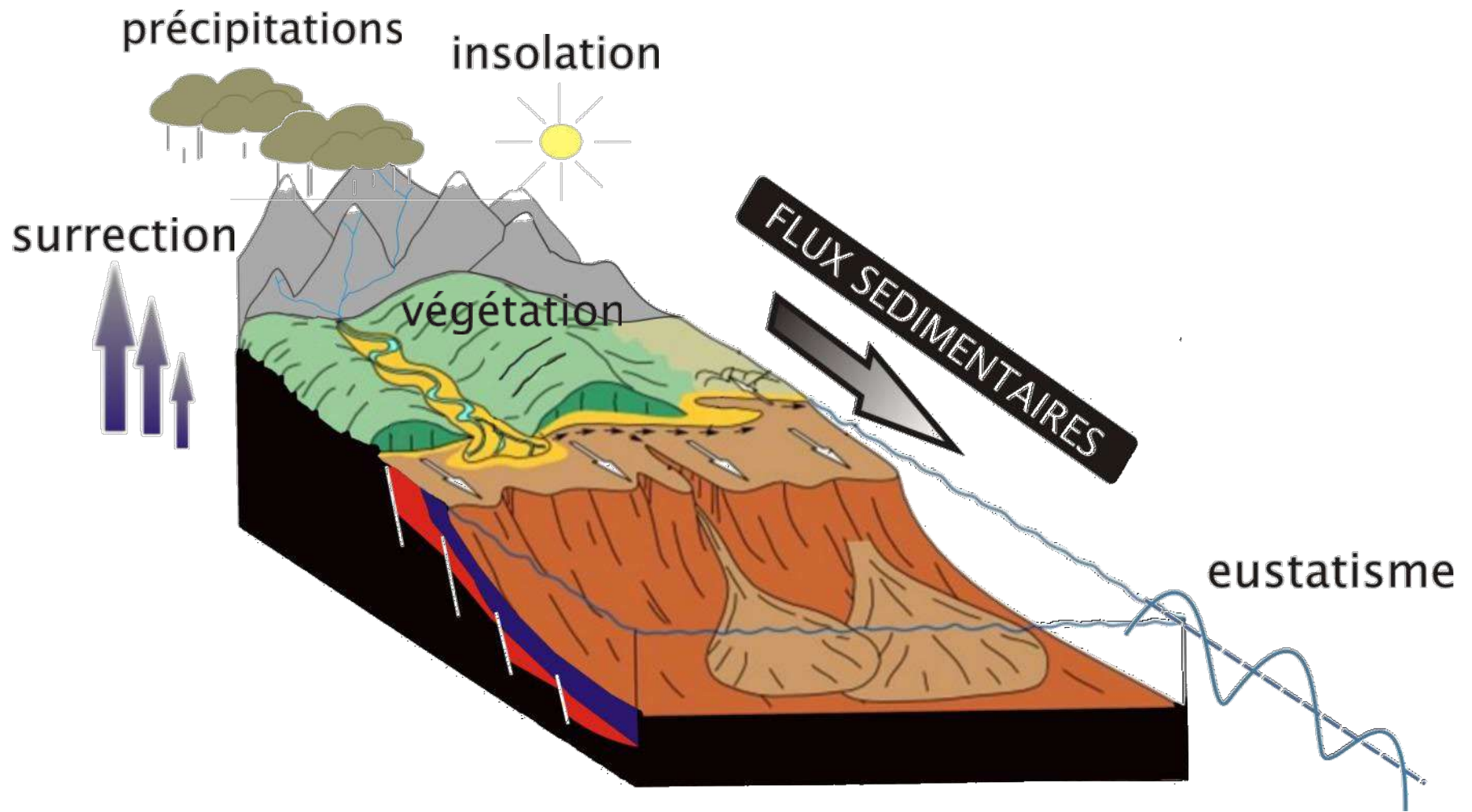
Bac 3 Géologie  
Master 1r géologues

Master Géologie

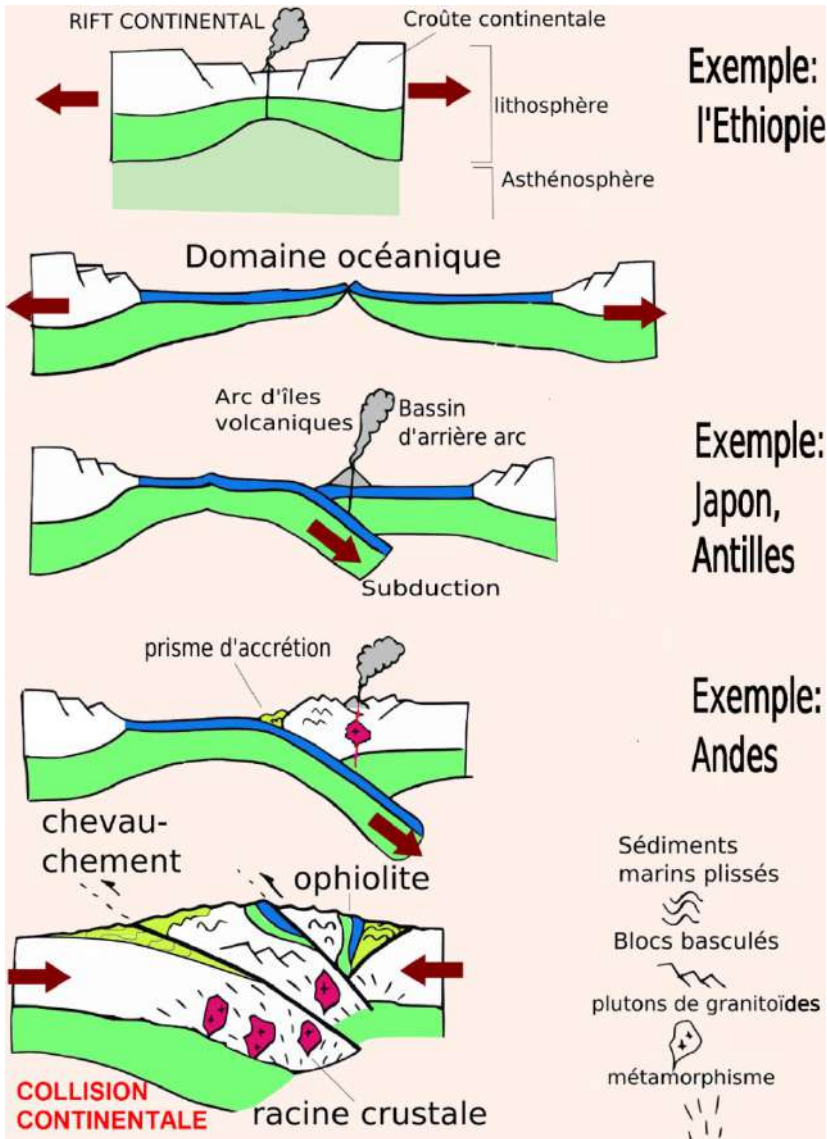










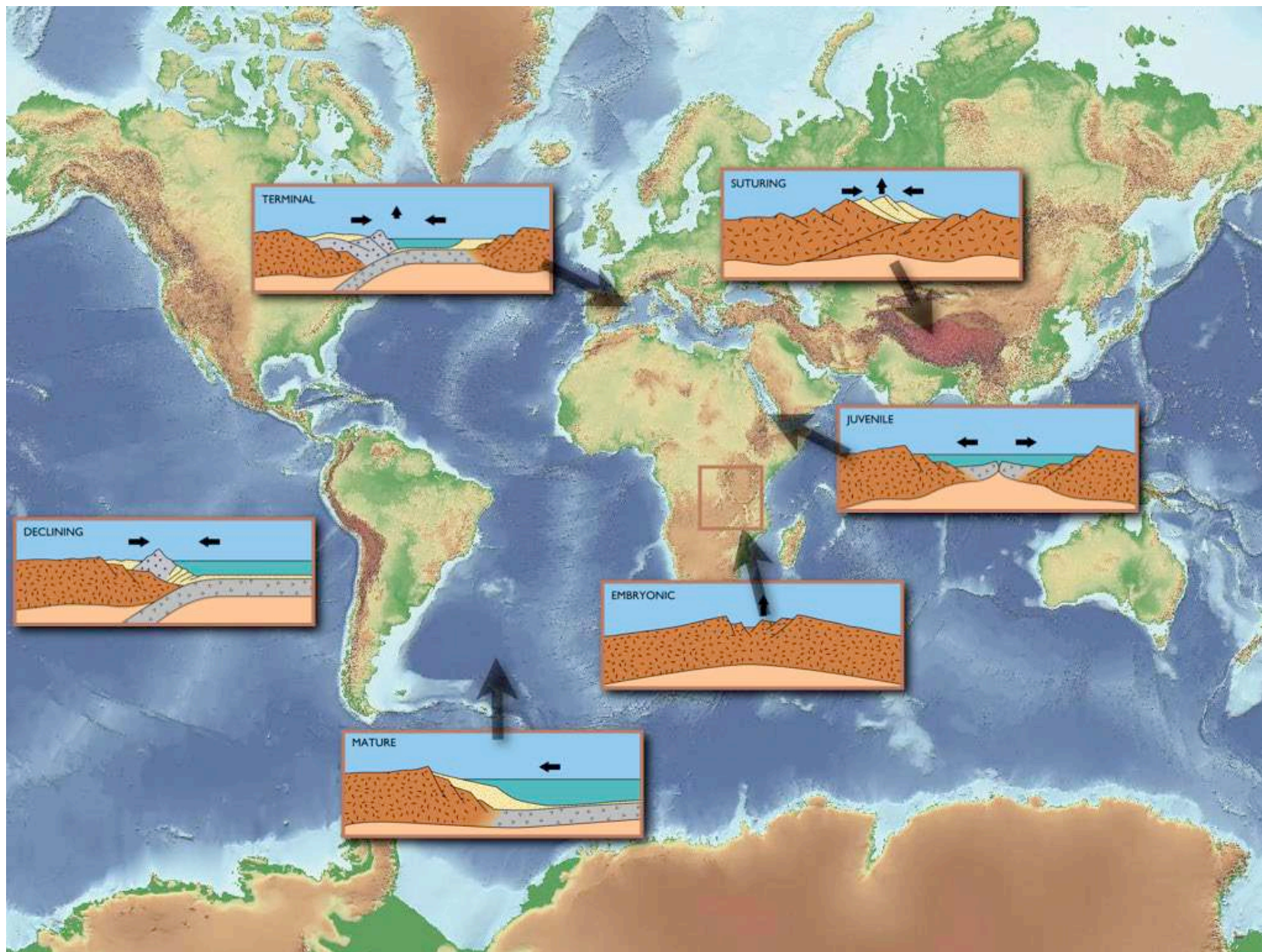


Exemple:  
l'Ethiopie

Exemple:  
Japon,  
Antilles

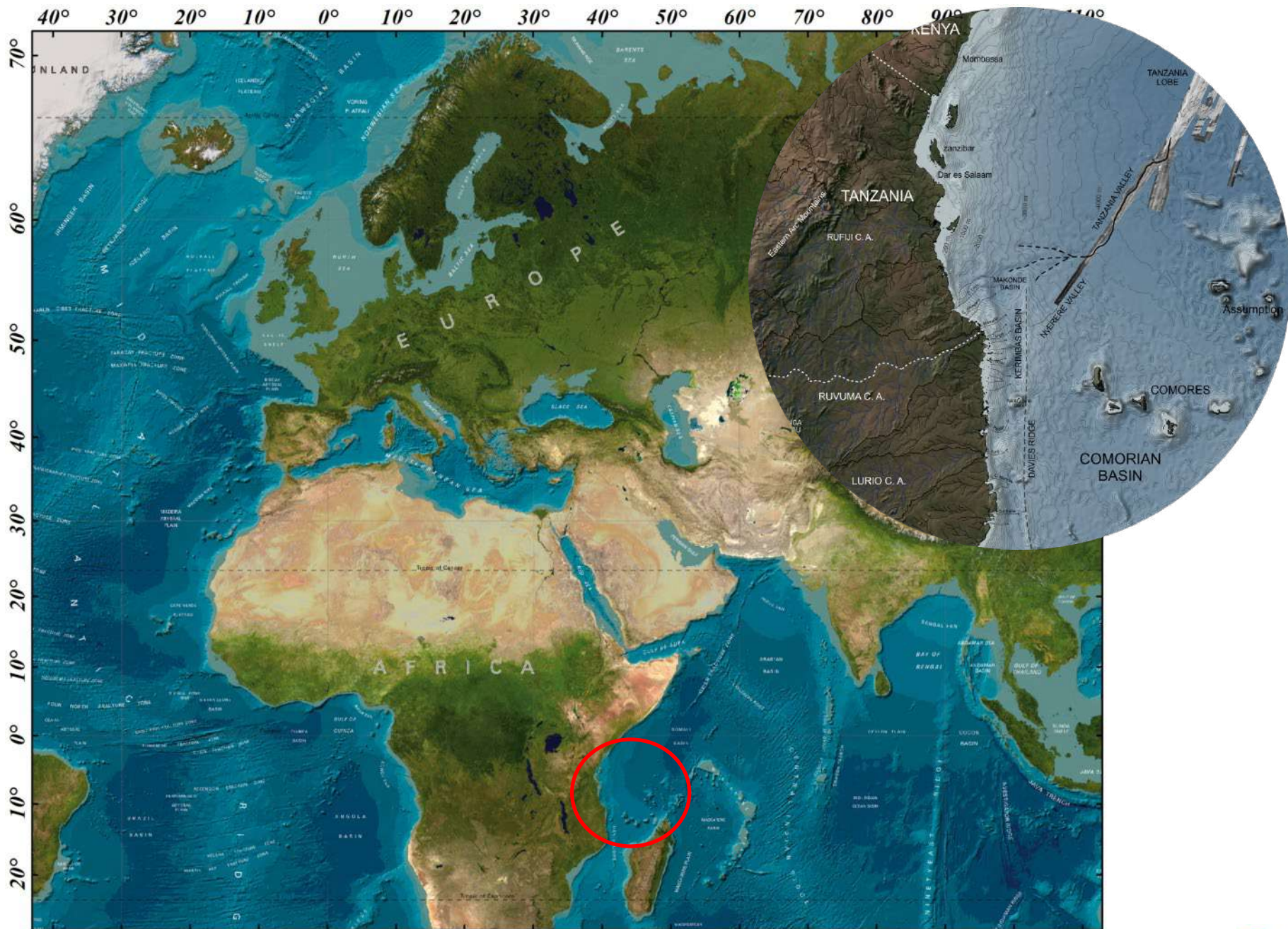
Exemple:  
Andes

[http://fr.wikipedia.org/wiki/Cycle\\_de\\_Wilson](http://fr.wikipedia.org/wiki/Cycle_de_Wilson)

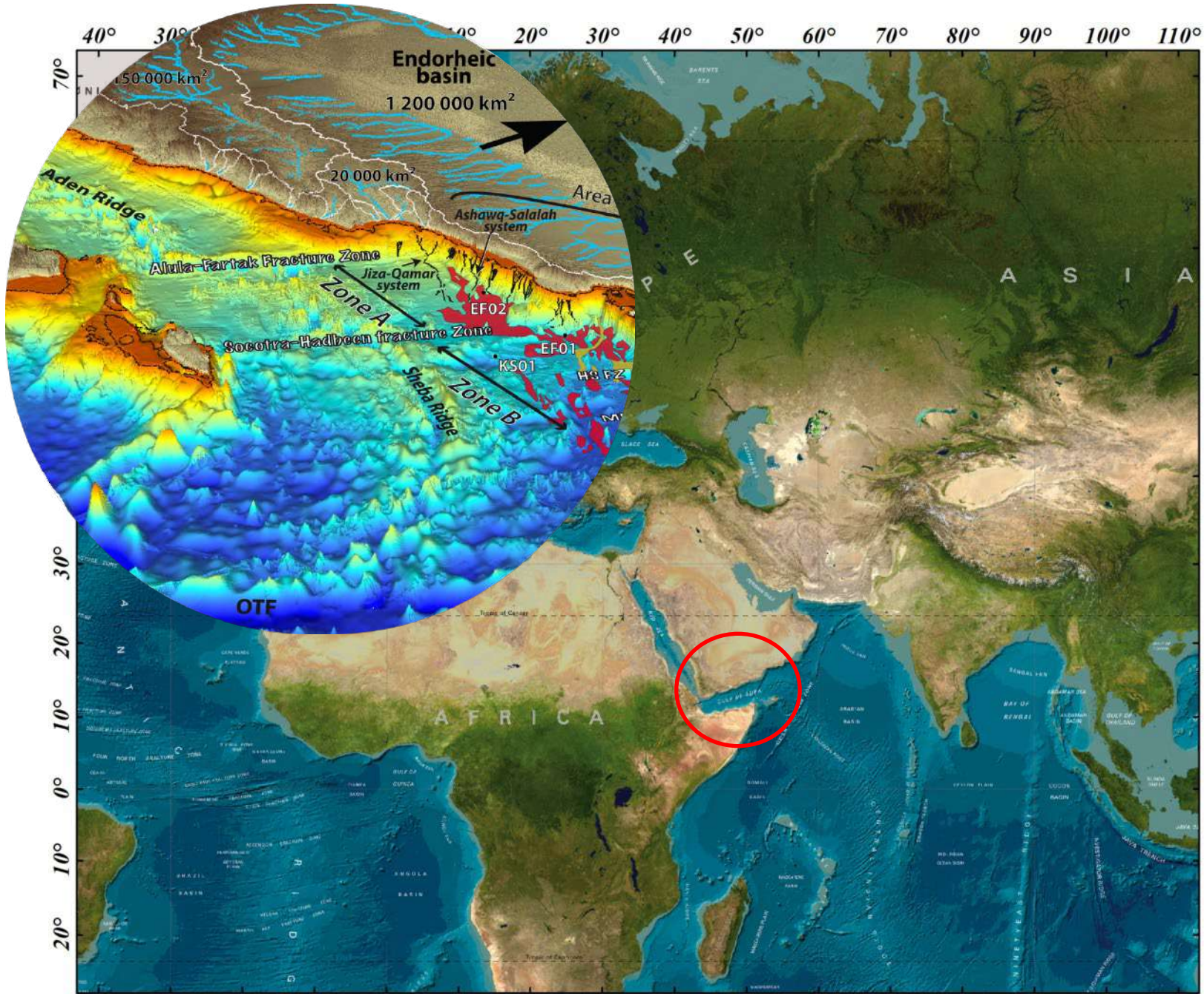


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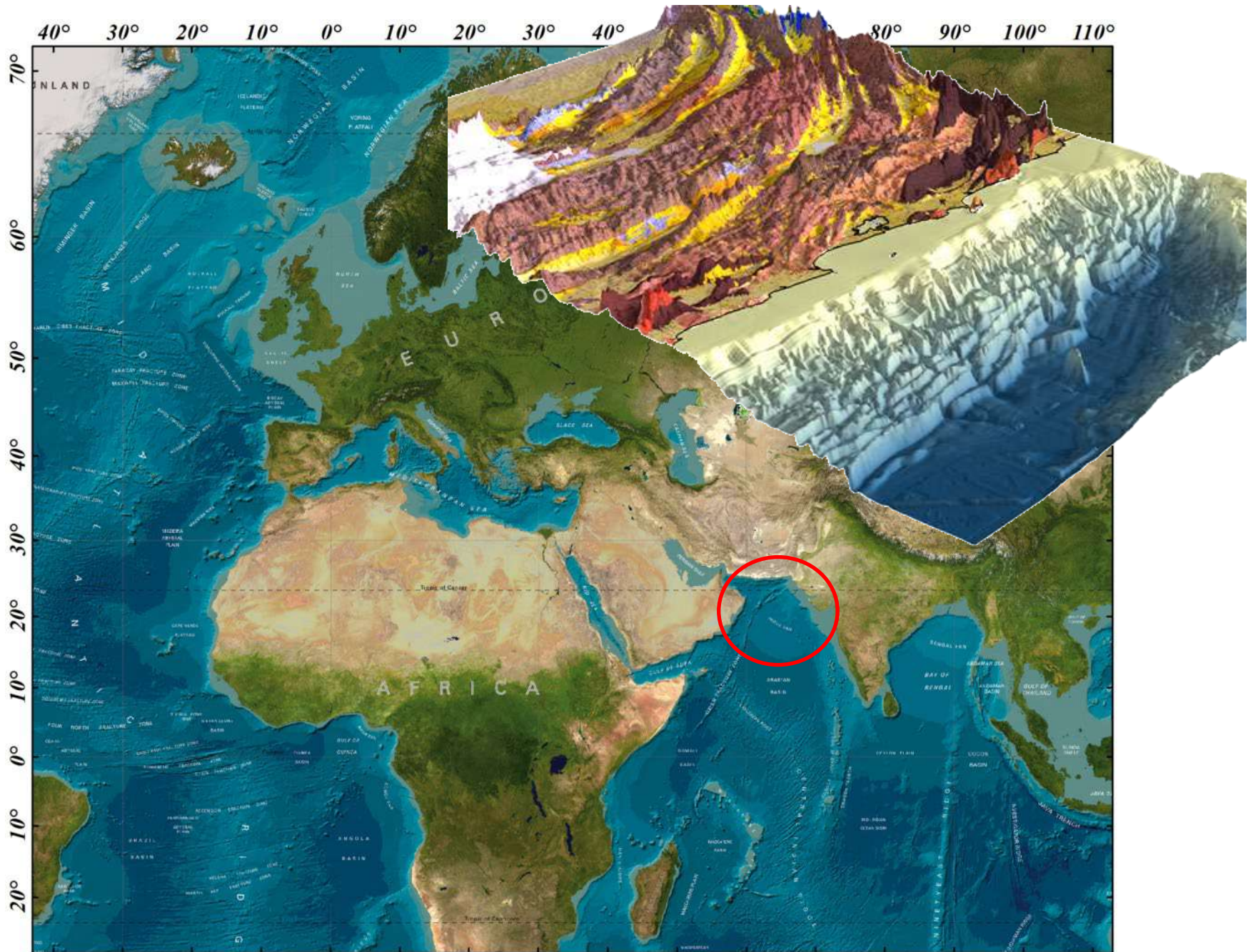




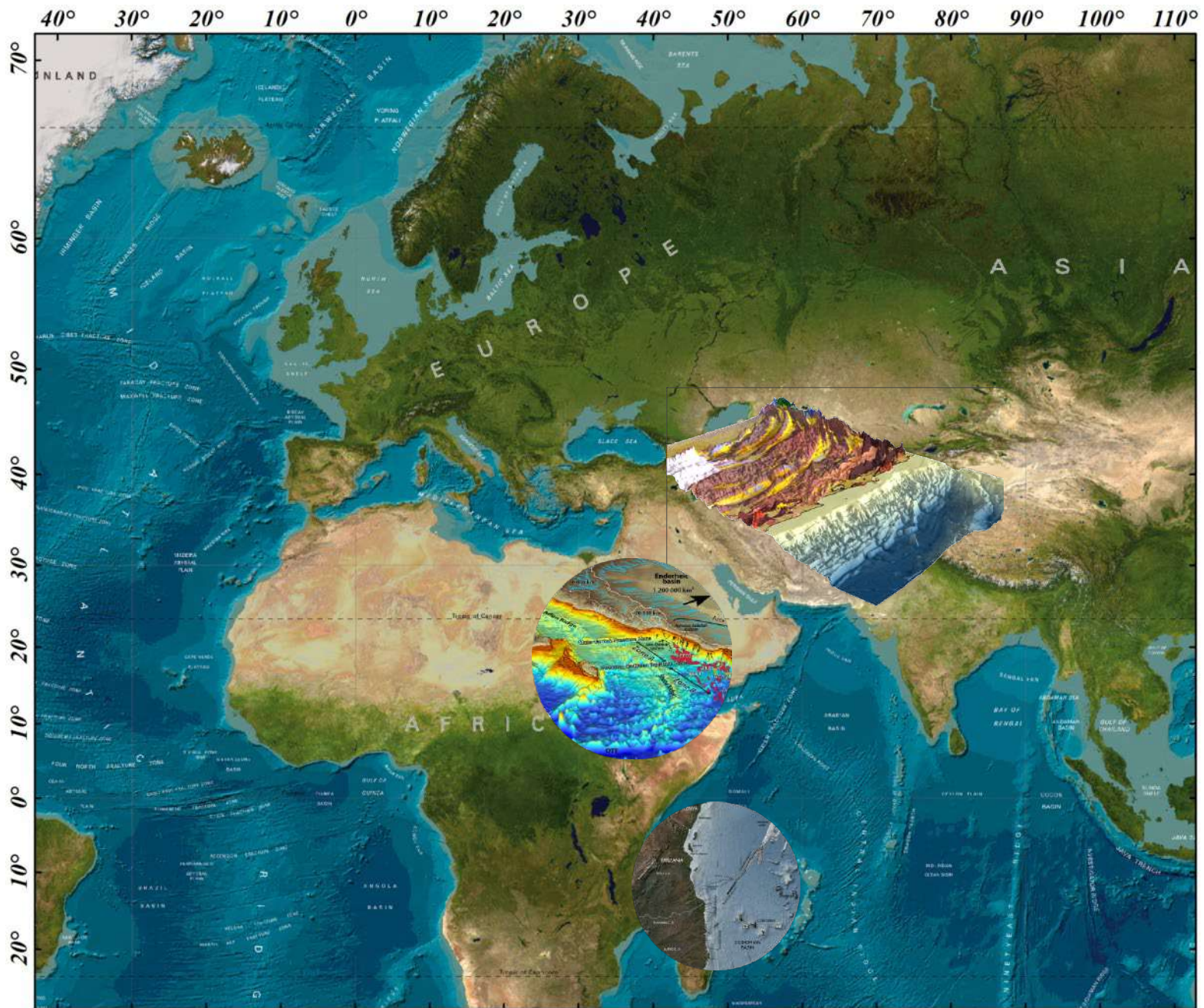






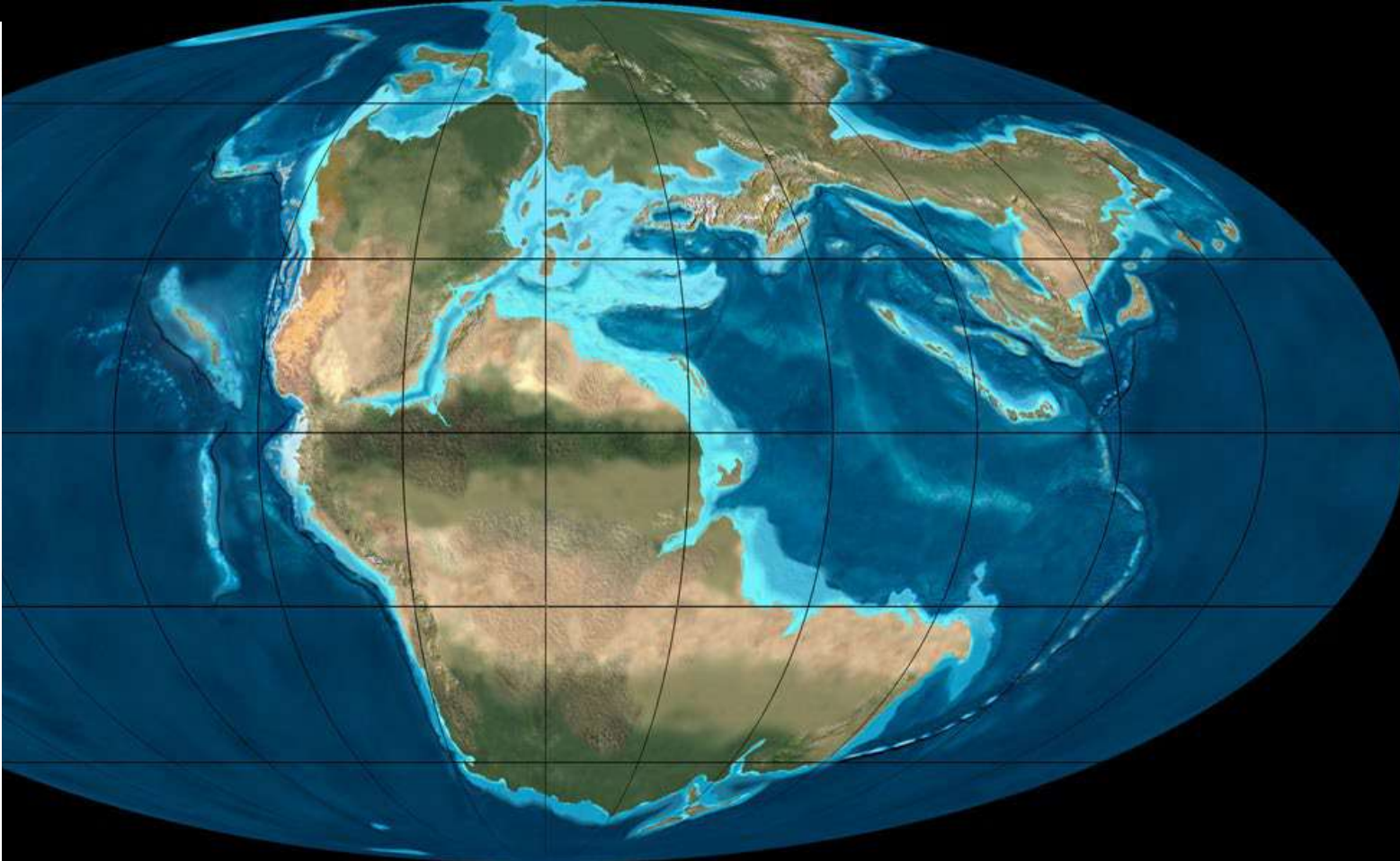




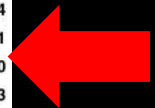




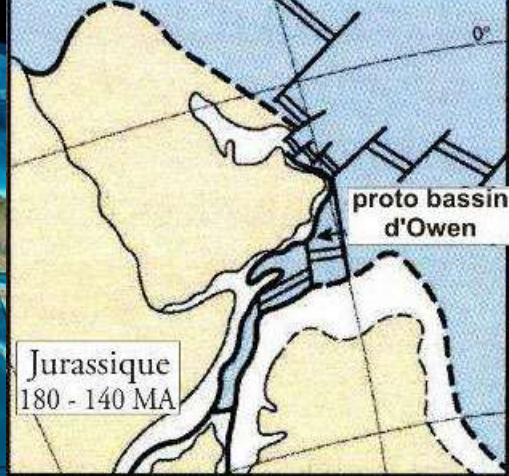
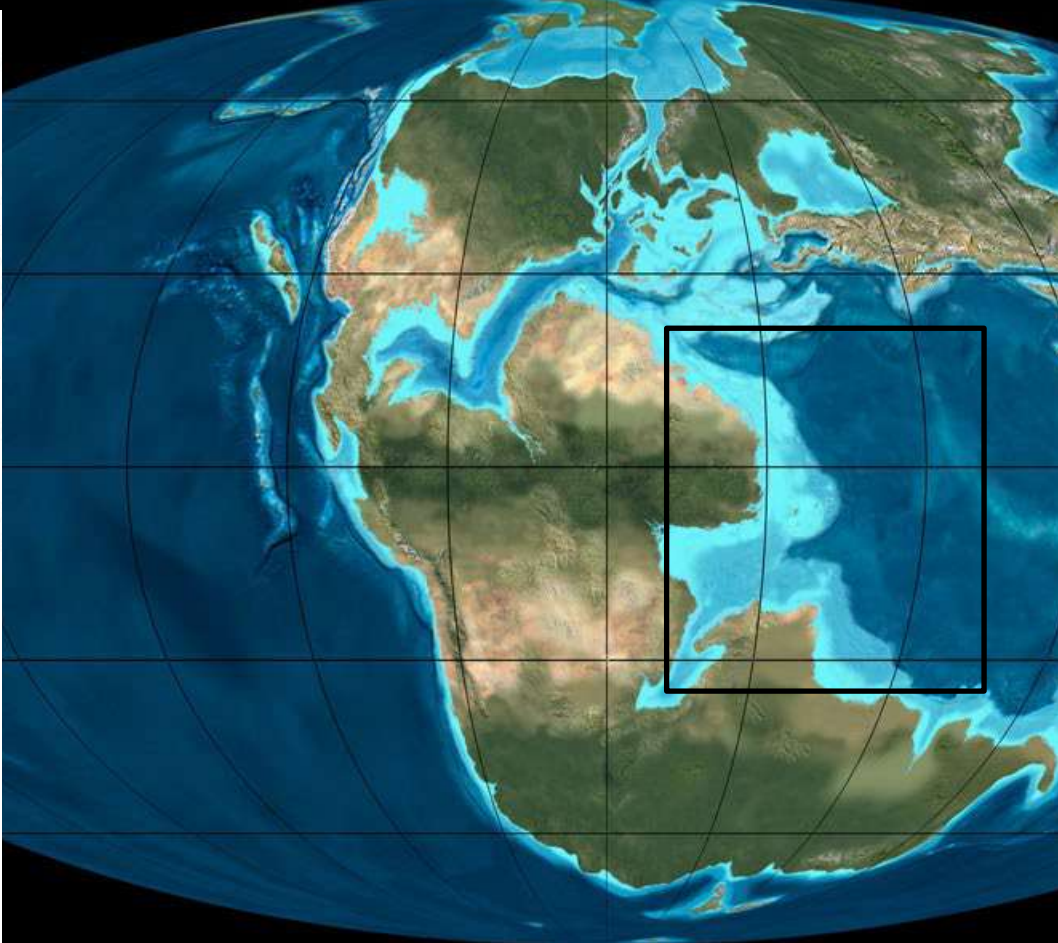
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	MESSINIEN	7,1	
<b>MIOCÈNE</b>	TORTONIEN	11,0	
	SERRAVALLIEN	14,7	
	LANGHIEN	15,8	
	BURDIGALIEN	20,3	
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<b>OLIGOCÈNE</b>	RUPÉLIEN	33,7	
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	YPRÉSIEN	53	
	THANÉTIEN	59	
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	<b>INFÉRIEUR</b>	ALBIEN	108
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BERRIASIEN		135	
TITHONIEN		141	
<b>SUPÉRIEUR (MALM)</b>	KIMMÉRIDGIEN	146	
	OXFORDIEN	154	
	CALLOVIEN	160	
	BATHONIEN	164	
<b>MOYEN (DOGGER)</b>	BAJOCIEN	170	
	AALÉNIEN	175	
	TOARCIEN	184	
<b>INFÉRIEUR (LIAS)</b>	PLIENSBACHIEN	191	
	SINÉMURIEN	200	
	HETTANGIEN	203	
<b>SUPÉRIEUR</b>	RHÉTIEN	-	
	NORIEN	220	
	CARNIEN	230	
	LADINIEN	233	
	ANISIEN	240	
<b>MOYEN</b>	LADINIEN	233	
	ANISIEN	240	
<b>INFÉRIEUR</b>	OLENEKIEN	-	
	INDUSIEN	250	



Jurassique : éclatement du Gondwana



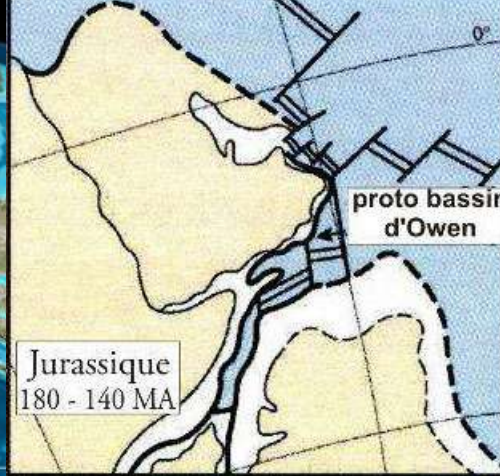
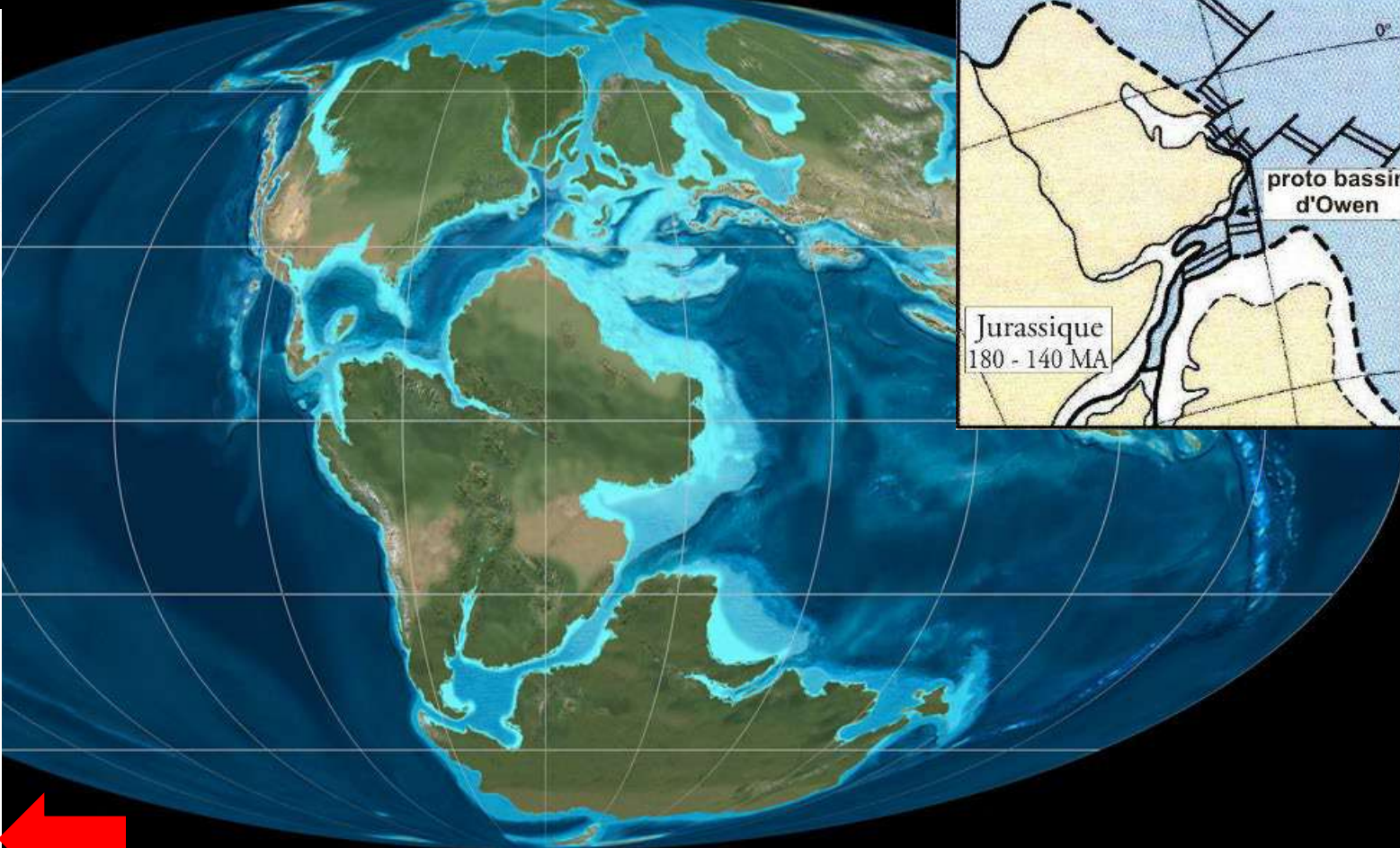
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		MESSINIEN	5,3	
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		CHATTIEN	23,0	
	<b>OLIGOCÈNE</b>	RUPÉLIEN	28	
		PRIABONIEN	33,7	
	<b>ÉOCÈNE</b>	BARTONIEN	37,0	
		LUTÉTIEN	40	
		YPRÉSIEN	46,0	
		THANÉTIEN	53	
	<b>PALÉOCÈNE</b>	DANIEN	59	
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		BERRIASIEN	131	
<b>JURASSIQUE</b>		<b>SUPÉRIEUR (MALM)</b>	TITHONIEN	135
			KIMMÉRIDGIEN	141
			OXFORDIEN	146
		<b>MOYEN (DOGGER)</b>	CALLOVIEN	154
			BATHONIEN	160
			BAJOCIEN	164
	AALÉNIEN		170	
	<b>INFÉRIEUR (LIAS)</b>	TOARCIEN	175	
		PLIENSBACHIEN	184	
		SINÉMURIEN	191	
<b>TRIAS</b>	<b>SUPÉRIEUR</b>	HETTANGIEN	200	
		RHÉTIEN	203	
		NORIEN	-	
	<b>MOYEN</b>	CARNIEN	220	
		LADINIEN	230	
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Jurassique : éclatement du Gondwana



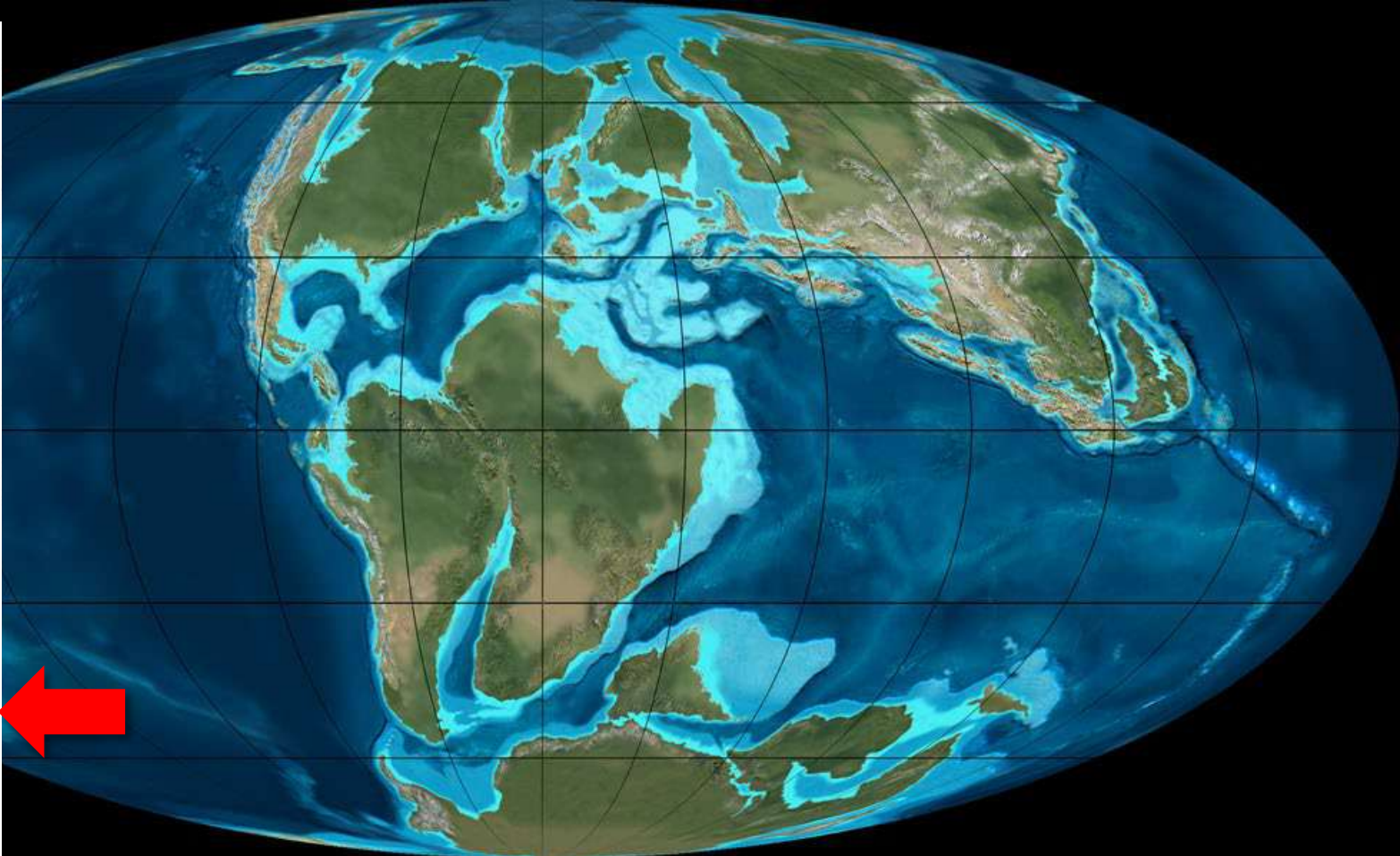
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		BURDIGALIEN	15,8
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		CHATTIEN	23,0
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	<b>ÉOCÈNE</b>	BARTONIEN	37,0
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	AALÉNIEN	170	
	TOARCIEN	175	
<b>INFÉRIEUR (LIAS)</b>	PLIENSBACHIEN	184	
	SINÉMURIEN	191	
	HETTANGIEN	200	
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		CARNIEN	220
	<b>MOYEN</b>	LADINIEN	230
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	<b>INFÉRIEUR</b>	OLENEKIEN	240
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		250	



Jurassique : éclatement du Gondwana



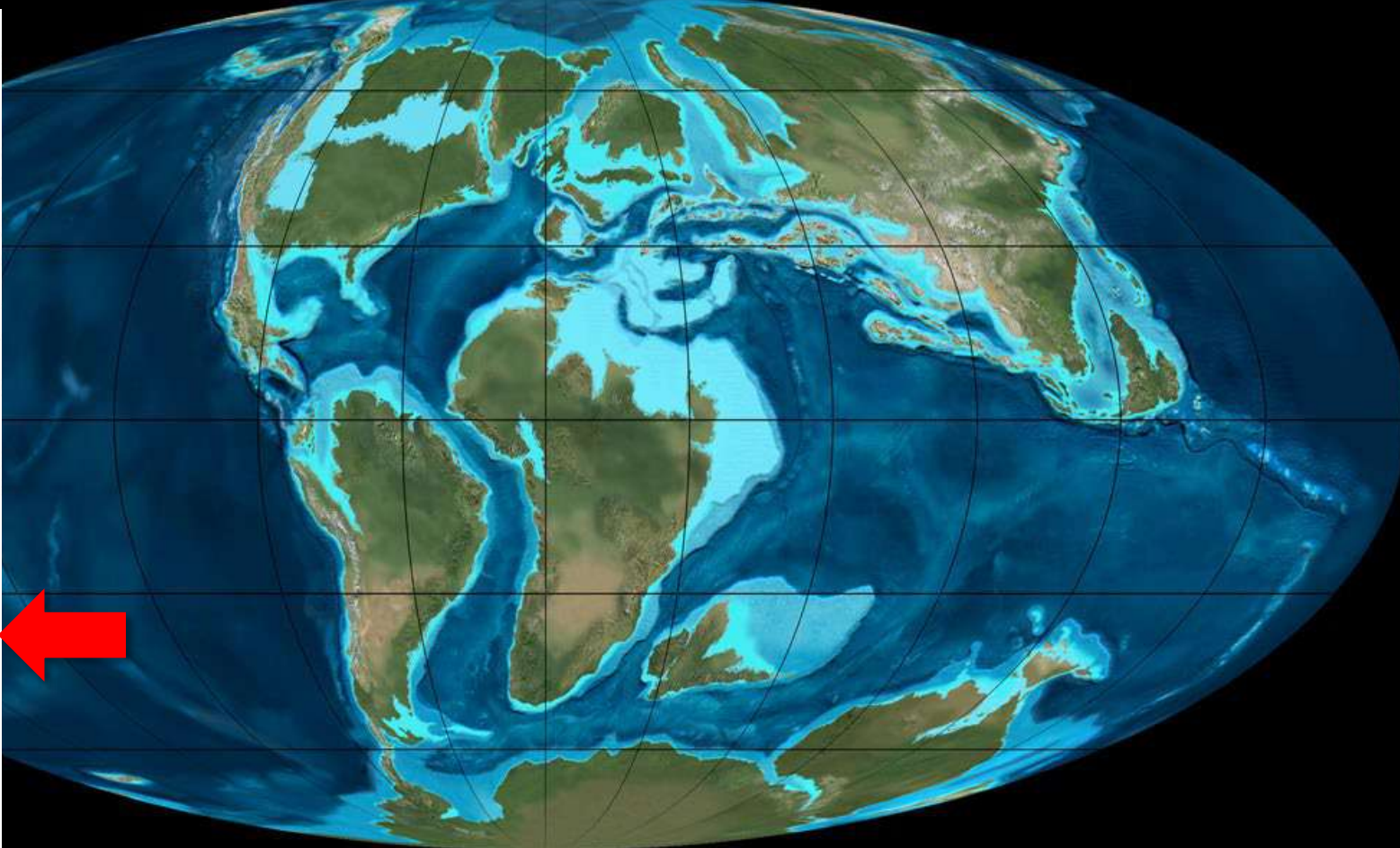
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		5,3
		7,1
	<b>MIOCÈNE</b>	11,0
		SERRAVALLIEN
		14,7
		LANGHIEN
		15,8
		20,3
	<b>OLIGOCÈNE</b>	23,0
		28
	<b>ÉOCÈNE</b>	33,7
		*
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		40
		46,0
<b>PALÉOCÈNE</b>	53	
	59	
<b>MÉSOZOÏQUE</b>	DANIEN	
	65,0	
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	CAMPANIEN	
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	CONIACIEN	
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	TURONIEN	
	92	
	CÉNOMANIEN	
	96	
	ALBIEN	
108		
APTIEN		
113		
<b>INFÉRIEUR</b>	BARRÉMIEN	
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	HAUTERVIVIEN	
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BERRIASIEN		
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	NORIEN	
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<b>MOYEN</b>	LADINIEN	
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ANISIEN		
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INDUSIEN		
250		



Crétacé : ouverture de l'océan Indien



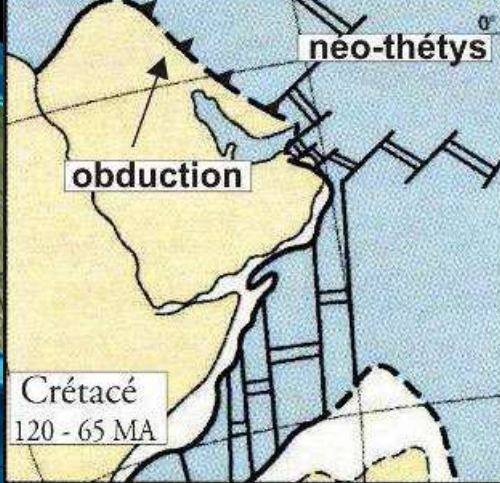
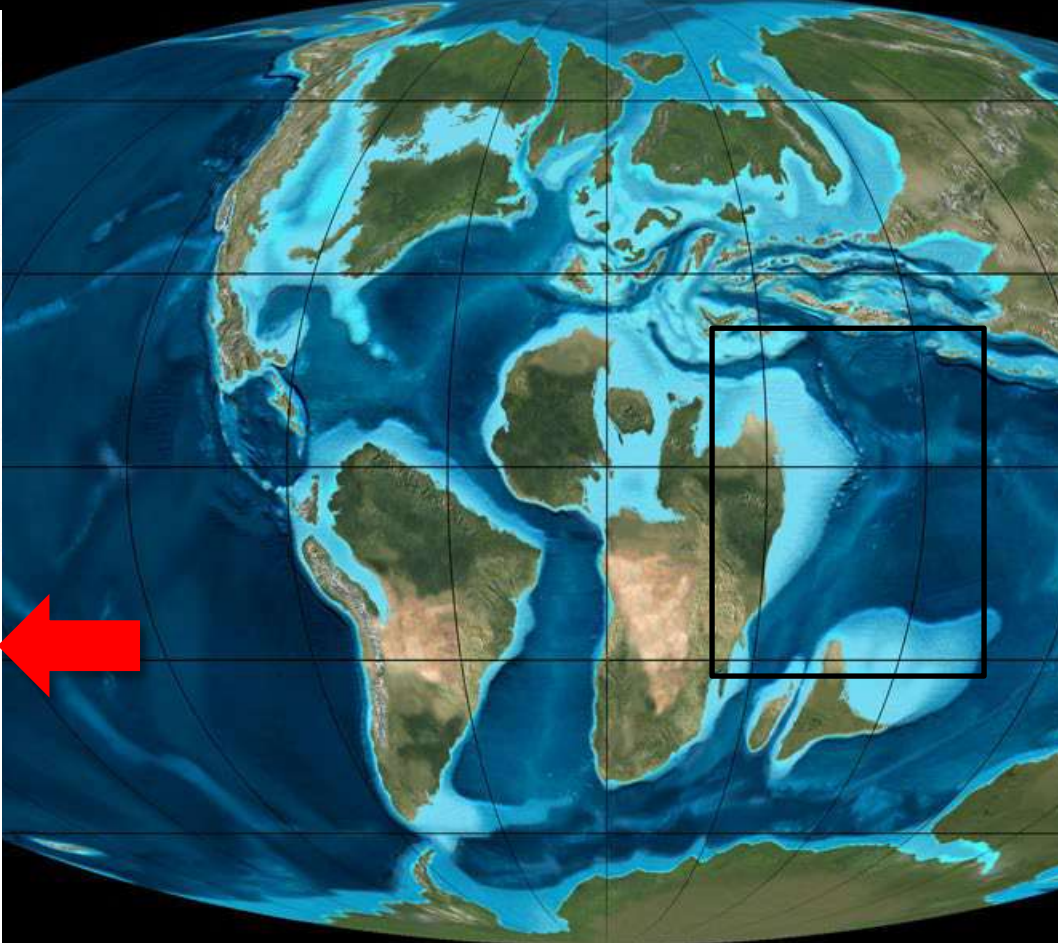
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	MESSINIEN	7,1	
<b>MIOCÈNE</b>	TORTONIEN	11,0	
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	LANGHIEN	15,8	
	BURDIGALIEN	20,3	
	AQUITANIEN	23,0	
	CHATTIEN	28	
<b>OLIGOCÈNE</b>	RUPÉLIEN	33,7	
	PRIABONIEN	37,0	
	BARTONIEN	40	
	LUTÉTIEN	46,0	
<b>ÉOCÈNE</b>	YPRÉSIEN	53	
	THANÉTIEN	59	
	DANIEN	65,0	
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	CAMPANIEN	83	
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	<b>INFÉRIEUR</b>	ALBIEN	108
		APTIEN	113
		BARRÉMIEN	117
		HAUTERIVIEN	123
		VALANGINIEN	131
BERRIASIEN	135		
<b>JURASSIQUE</b>	TITHONIEN	141	
	<b>SUPÉRIEUR (MALM)</b>	KIMMÉRIDIEN	146
		OXFORDIEN	154
		CALLOVIEN	160
	<b>MOYEN (DOGGER)</b>	BATHONIEN	164
		BAJOCIEN	170
		AALÉNIEN	175
		TOARCIEN	184
	<b>INFÉRIEUR (LIAS)</b>	PLIENSBACHIEN	191
		SINÉMURIEN	200
HETTANGIEN		203	
<b>TRIAS</b>	RHÉTIEN	-	
	<b>SUPÉRIEUR</b>	NORIEN	220
		CARNIEN	230
		LADINIEN	233
	<b>MOYEN</b>	ANISIEN	240
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	INDUSIEN		250



Crétacé : ouverture de l'océan Indien



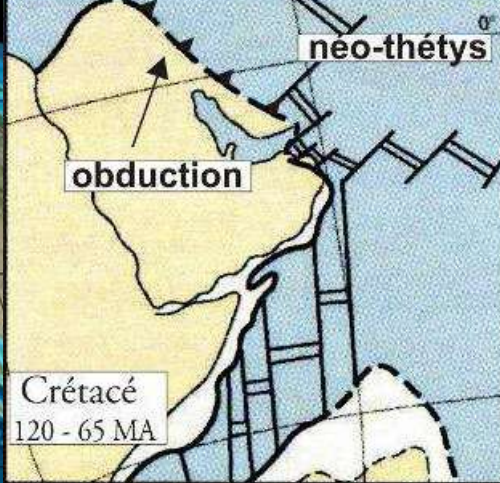
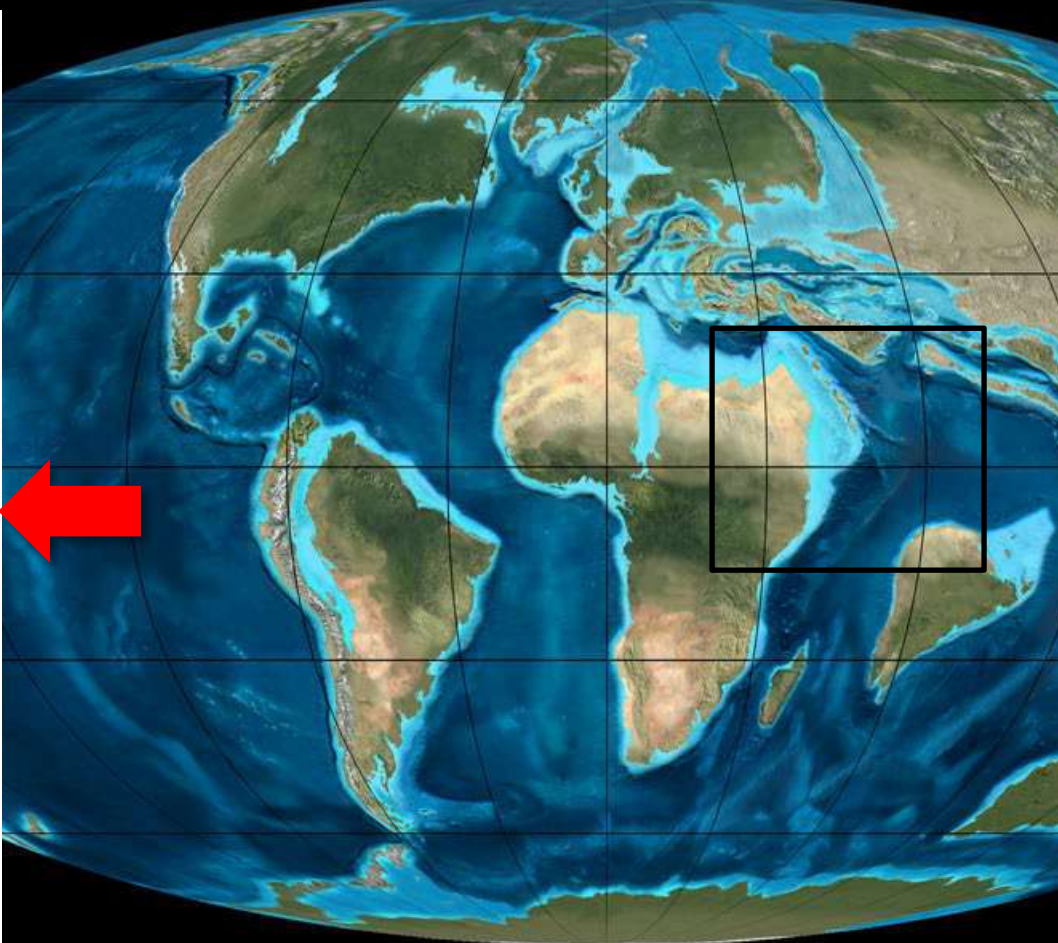
<b>CÉNZOÏQUE</b>	<b>QUATERNAIRE</b>		Ma	
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		ZANCLÉIEN	3,4	
		MESSINIEN	5,3	
	<b>MIOCÈNE</b>	TORTONIEN	7,1	
		SERRAVALLIEN	11,0	
		LANGHIEN	14,7	
		BURDIGALIEN	15,8	
		AQUITANIEN	20,3	
	<b>OLIGOCÈNE</b>	CHATTIEN	23,0	
		RUPÉLIEN	28	
	<b>ÉOCÈNE</b>	PRIABONIEN	33,7	
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	DANIEN	59		
<b>MÉSOZOÏQUE</b>	<b>CRÉTACÉ</b>	MAASTRICHTIEN	65,0	
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		TURONIEN	88	
		CÉNOMANIEN	92	
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		BARRÉMIEN	113	
		HAUTERIVIEN	117	
		VALANGINIEN	123	
	<b>JURASSIQUE</b>	<b>SUPÉRIEUR (MALM)</b>	BERRIASIEN	131
			TITHONIEN	135
			KIMMÉRIDIEN	141
		<b>MOYEN (DOGGER)</b>	OXFORDIEN	146
CALLOVIEN			154	
BATHONIEN			160	
BAJOCIEN			164	
<b>INFÉRIEUR (LIAS)</b>		AALÉNIEN	170	
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	PLIENSBACHIEN	184		
<b>TRIAS</b>	<b>SUPÉRIEUR</b>	HETTANGIEN	191	
		SINÉMURIEN	200	
		RHÉTIEN	203	
	<b>MOYEN</b>	NORIEN	220	
		CARNIEN	230	
		LADINIEN	233	
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	OLENEKIEN	240		
	INDUSIEN	250		



Crétacé : ouverture de l'océan Indien



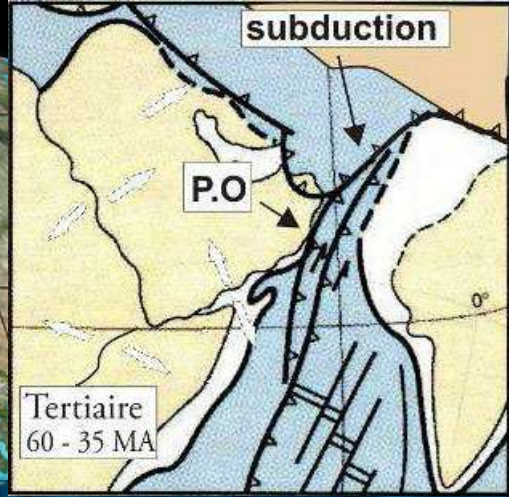
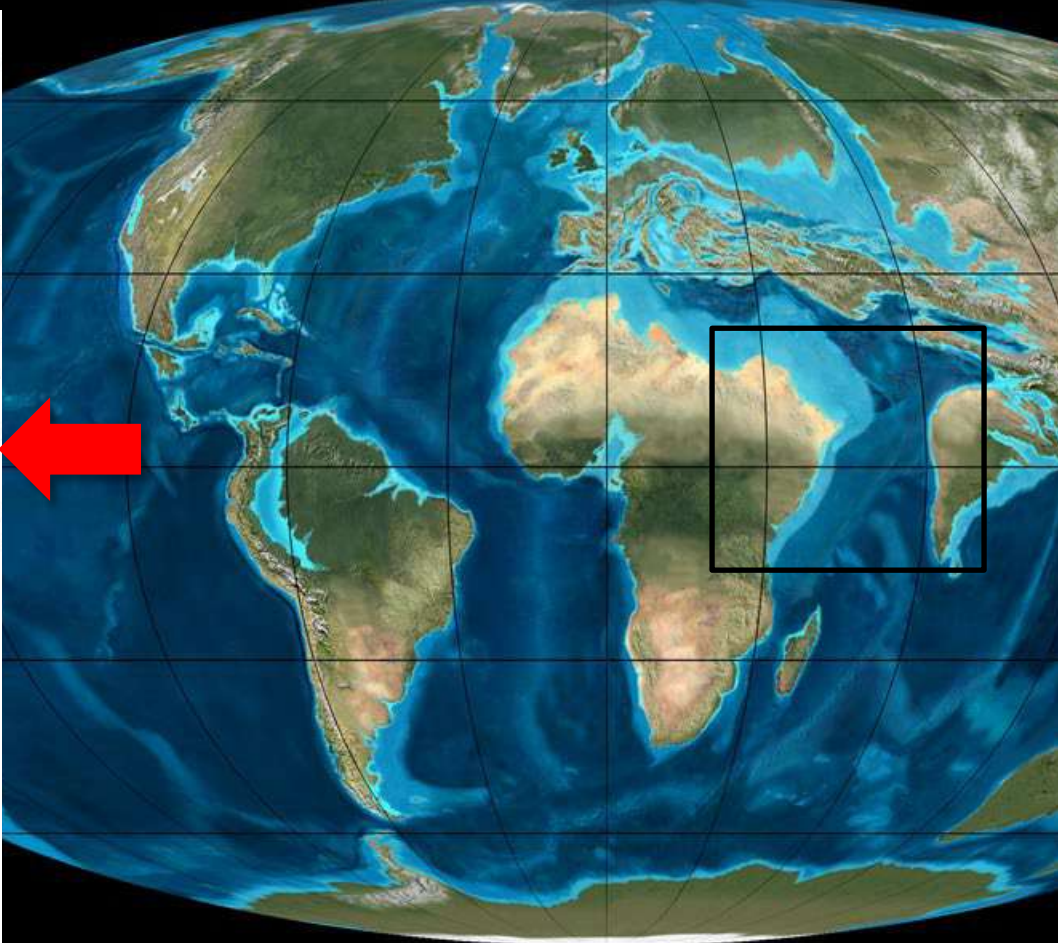
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		ZANCLÉIEN	3,4
		MESSINIEN	5,3
	<b>MIOCÈNE</b>	TORTONIEN	7,1
		SERRAVALLIEN	11,0
		LANGHIEN	14,7
		BURDIGALIEN	15,8
		AQUITANIEN	20,3
	<b>OLIGOCÈNE</b>	CHATTIEN	23,0
RUPÉLIEN		28	
<b>ÉOCÈNE</b>	PRIABONIEN	33,7	
	BARTONIEN	37,0	
	LUTÉTIEN	40	
	YPRESIEN	46,0	
<b>PALÉOCÈNE</b>	THANÉTIEN	53	
	DANIEN	59	
<b>MÉSOZOÏQUE</b>	<b>CRÉTACÉ</b>	MAASTRICHTIEN	65,0
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		SANTONIEN	83
		CONIACIEN	87
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		ALBIEN	96
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		BARRÉMIEN	113
		HAUTERIVIEN	117
VALANGINIEN	123		
<b>JURASSIQUE</b>	<b>SUPÉRIEUR (MALM)</b>	BERRIASIEN	131
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		CARNIEN	230
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Crétacé : ouverture de l'océan Indien

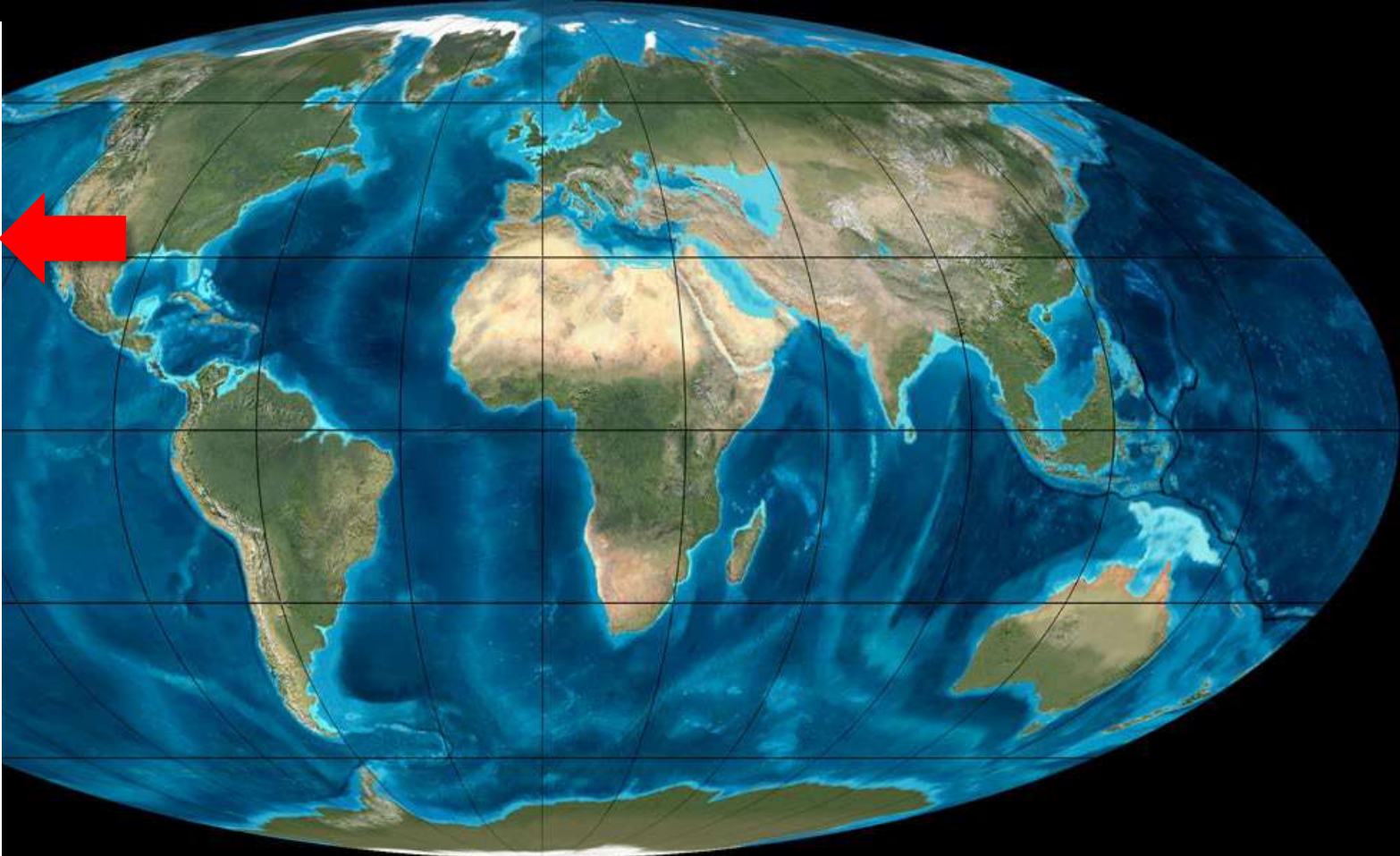


<b>CÉNZOÏQUE</b>	<b>QUATERNAIRE</b>		Ma
	<b>PLIOCÈNE</b>	PLAISANCIEN	1,75
		ZANCLÉIEN	3,4
		MESSINIEN	5,3
	<b>MIOCÈNE</b>	TORTONIEN	7,1
		SERRAVALLIEN	11,0
		LANGHIEN	14,7
		BURDIGALIEN	15,8
		AQUITANIEN	20,3
	<b>OLIGOCÈNE</b>	CHATTIEN	23,0
RUPÉLIEN		28	
<b>ÉOCÈNE</b>	PRIABONIEN	33,7	
	BARTONIEN	37,0	
	LUTÉTIEN	40	
	YPRESIEN	46,0	
<b>PALÉOCÈNE</b>	THANÉTIEN	53	
	DANIEN	59	
<b>MÉSOZOÏQUE</b>	<b>CRÉTACÉ</b>	MAASTRICHTIEN	65,0
		CAMPANIEN	72,0
		SANTONIEN	83
		CONIACIEN	87
		TURONIEN	88
	<b>INFÉRIEUR</b>	CÉNOMANIEN	92
		ALBIEN	96
		APTIEN	108
		BARRÉMIEN	113
		HAUTERIVIEN	117
<b>JURASSIQUE</b>	<b>SUPÉRIEUR (MALM)</b>	VALANGINIEN	123
		BERRIASIEN	131
		TITHONIEN	135
	<b>MOYEN (DOGGER)</b>	KIMMÉRIDGIEN	141
		OXFORDIEN	146
		CALLOVIEN	154
		BATHONIEN	160
<b>INFÉRIEUR (LIAS)</b>	BAJOCIEN	164	
	AALÉNIEN	170	
	TOARCIEN	175	
<b>TRIAS</b>	<b>SUPÉRIEUR</b>	PLIENSBACHIEN	184
		SINÉMURIEN	191
		HETTANGIEN	200
	<b>MOYEN</b>	RHÉTIEN	203
		NORIEN	220
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	ANISIEN	240	
	OLENEKIEN	240	
	INDUSIEN	250	





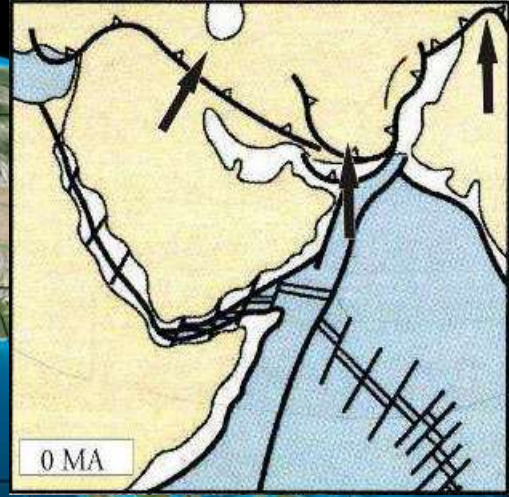
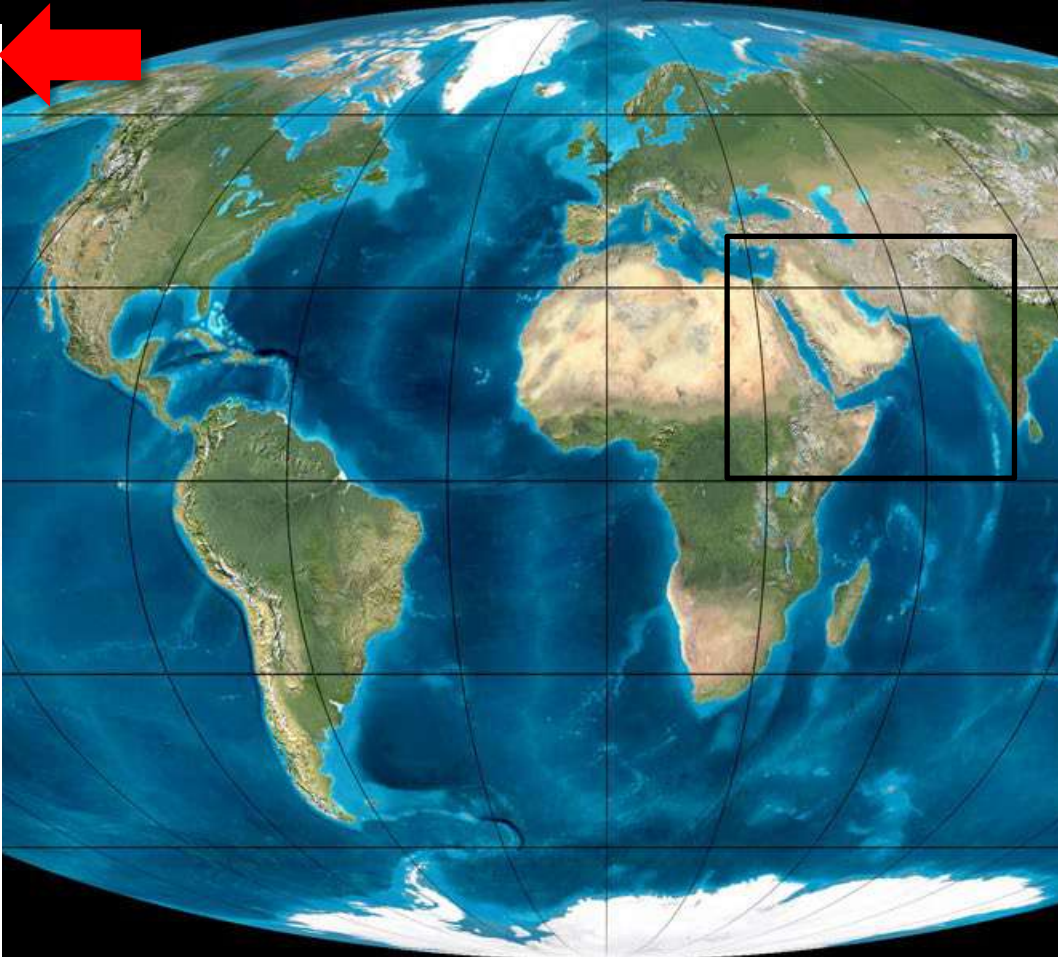
<b>CÉNZOÏQUE</b>	<b>QUATERNAIRE</b>		Ma	
	<b>PLIOCÈNE</b>	PLAISANCIEN	1,75	
		ZANCLÉIEN	3,4	
		MESSINIEN	5,3	
	<b>MIOCÈNE</b>	TORTONIEN	7,1	
		SERRAVALLIEN	11,0	
		LANGHIEN	14,7	
		BURDIGALIEN	15,8	
		AQUITANIEN	20,3	
		CHATTIEN	23,0	
	<b>OLIGOCÈNE</b>	RUPÉLIEN	28	
		PRIABONIEN	33,7	
	<b>ÉOCÈNE</b>	BARTONIEN	37,0	
		LUTÉTIEN	40	
		YPRÉSIEEN	46,0	
<b>PALÉOCÈNE</b>	THANÉTIEN	53		
	DANIEN	59		
<b>MÉSOZOÏQUE</b>	<b>CRÉTACÉ</b>	MAASTRICHTIEN	65,0	
		CAMPANIEN	72,0	
		SANTONIEN	83	
		CONIACIEN	87	
		TURONIEN	88	
		CÉNOMANIEN	92	
	<b>INFÉRIEUR</b>	ALBIEN	96	
		APTIEN	108	
		BARRÉMIEN	113	
		HAUTERIVIEN	117	
		VALANGINIEN	123	
		BERRIASIEN	131	
	<b>JURASSIQUE</b>	<b>SUPÉRIEUR (MALM)</b>	BERRIASIEN	135
			TITHONIEN	141
			KIMMÉRIDGIEN	146
<b>MOYEN (DOGGER)</b>		OXFORDIEN	154	
		CALLOVIEN	160	
		BATHONIEN	164	
<b>INFÉRIEUR (LIAS)</b>		BAJOCIEN	164	
		AALÉNIEN	170	
		TOARCIEN	175	
<b>TRIASS</b>	<b>SUPÉRIEUR</b>	TOARCIEN	184	
		PLIENSBACHIEN	191	
		SINÉMURIEN	200	
	<b>MOYEN</b>	HETTANGIEN	203	
		RHÉTIEN	-	
		NORIEN	220	
<b>INFÉRIEUR</b>	CARNIEN	230		
	LADINIEN	233		
	ANISIEN	240		
	SCYTHIEN	240		
	OLENEKIEN	-		
	INDUSIEN	250		



Oligocène - Actuel : ouverture du golfe d'Aden, de la mer Rouge et du rift est-africain



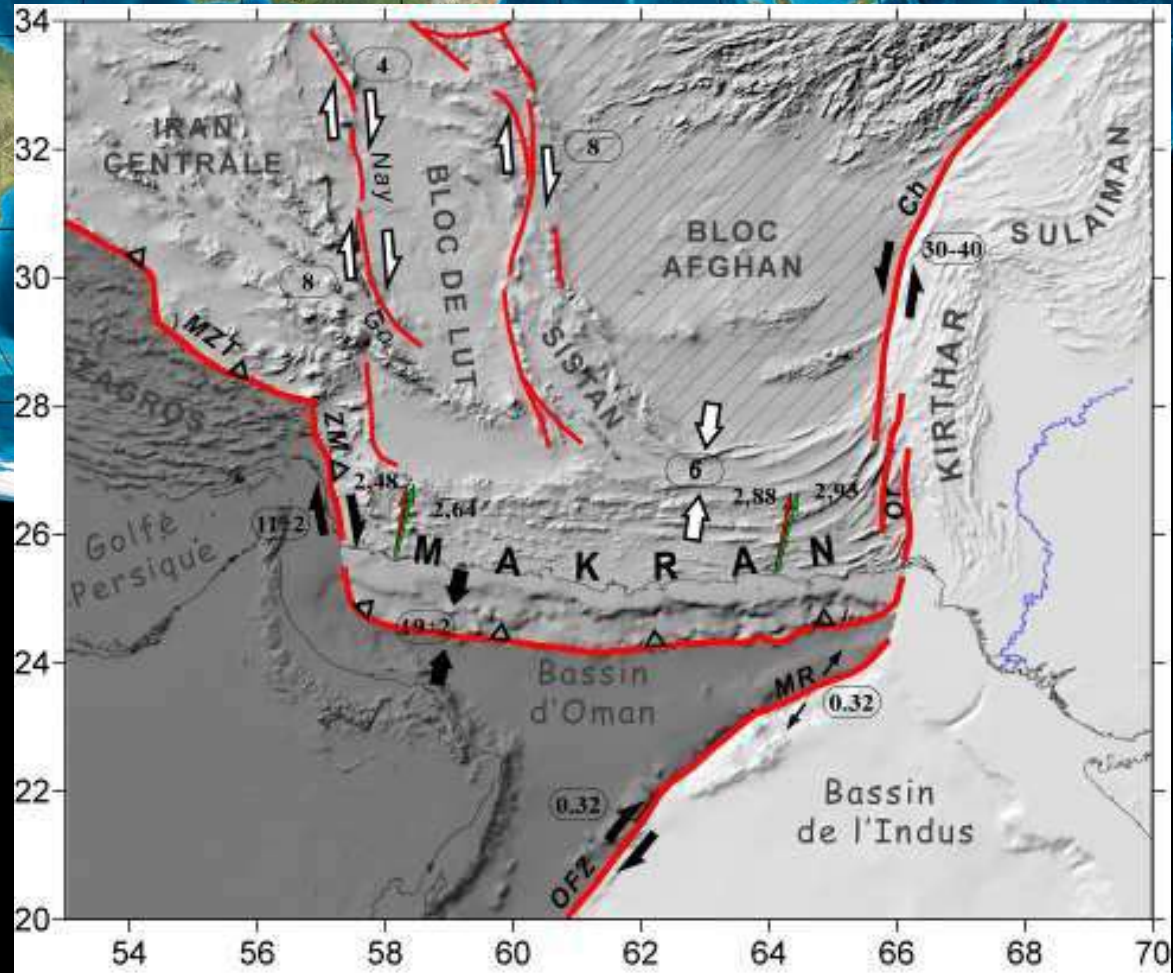
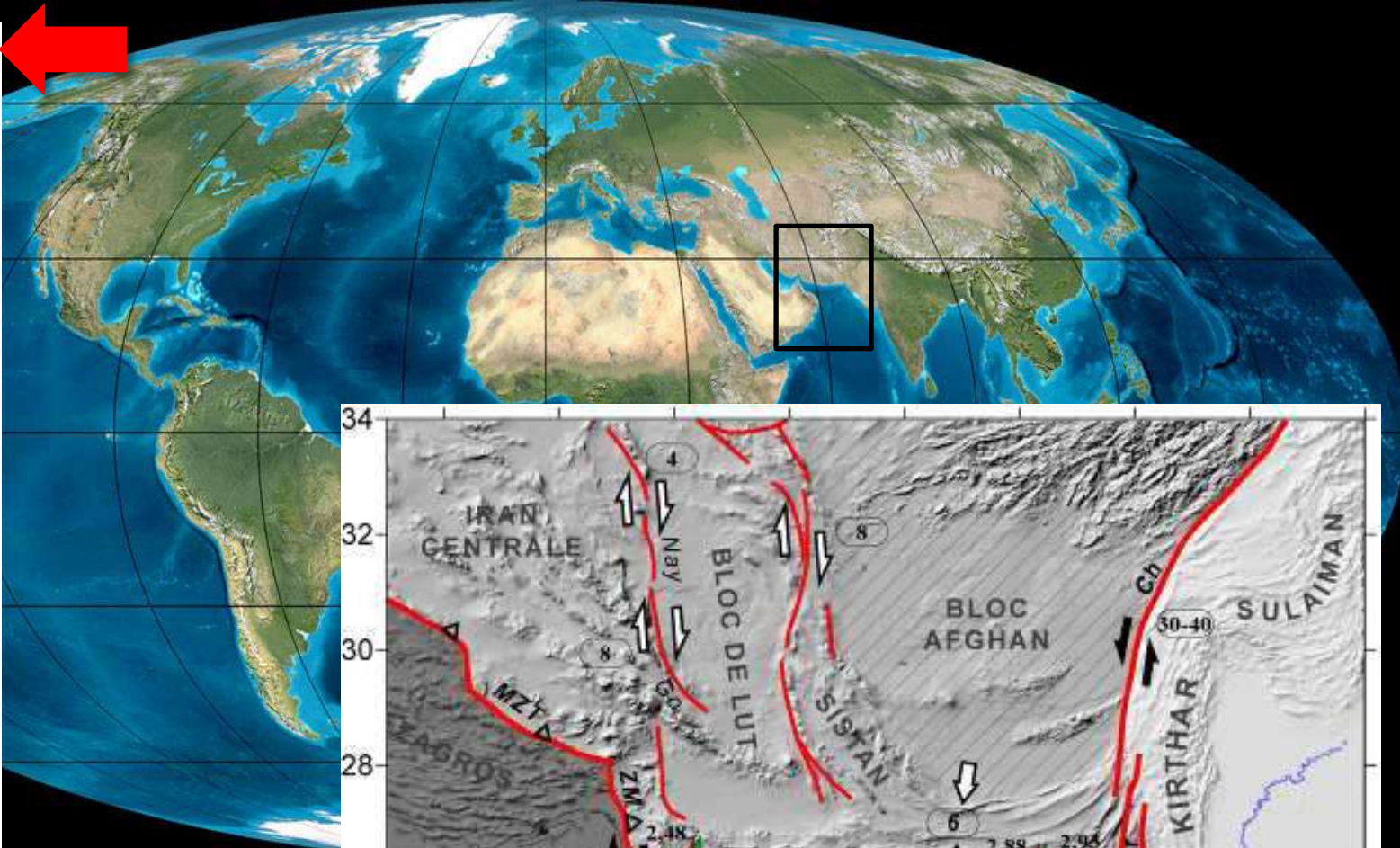
<b>CÉNZOÏQUE</b>	<b>QUATERNAIRE</b>		Ma
	<b>PLIOCÈNE</b>	PLAISANCIEN	1,75
		ZANCLÉIEN	3,4
		MESSINIEN	5,3
	<b>MIOCÈNE</b>	TORTONIEN	7,1
		SERRAVALLIEN	11,0
		LANGHIEN	14,7
		BURDIGALIEN	15,8
		AQUITANIEN	20,3
		CHATTIEN	23,0
	<b>OLIGOCÈNE</b>	RUPÉLIEN	28
		PRIABONIEN	33,7
	<b>ÉOCÈNE</b>	BARTONIEN	37,0
		LUTÉTIEN	40
YPRÉSIEN		46,0	
<b>PALÉOCÈNE</b>	THANÉTIEN	53	
<b>MÉSOZOÏQUE</b>	DANIEN	59	
	<b>CRÉTACÉ SUPÉRIEUR</b>	MAASTRICHTIEN	65,0
		CAMPANIEN	72,0
		SANTONIEN	83
		CONIACIEN	87
		TURONIEN	88
	<b>CRÉTACÉ INFÉRIEUR</b>	CÉNOMANIEN	92
		ALBIEN	96
		APTIEN	108
		BARRÉMIEN	113
		HAUTERVIVIEN	117
		VALANGINIEN	123
	<b>JURASSIQUE</b>	BERRIASIEN	131
		TITHONIEN	135
<b>SUPÉRIEUR (MALM)</b>		KIMMÉRIDGIEN	141
		OXFORDIEN	146
		CALLOVIEN	154
<b>MOYEN (DOGGER)</b>		BATHONIEN	160
		BAJOCIEN	164
		AALÉNIEN	170
		TOARCIEN	175
<b>INFÉRIEUR (LIAS)</b>		PLIENSBACHIEN	184
	SINÉMURIEN	191	
	HETTANGIEN	200	
<b>TRIAS</b>	HETTANGIEN	203	
	<b>SUPÉRIEUR</b>	RHÉTIEN	-
		NORIEN	220
		CARNIEN	230
	<b>MOYEN</b>	LADINIEN	233
ANISIEN		240	
<b>INFÉRIEUR</b>	OLENEKIEN	-	
	INDUSIEN	-	
		250	

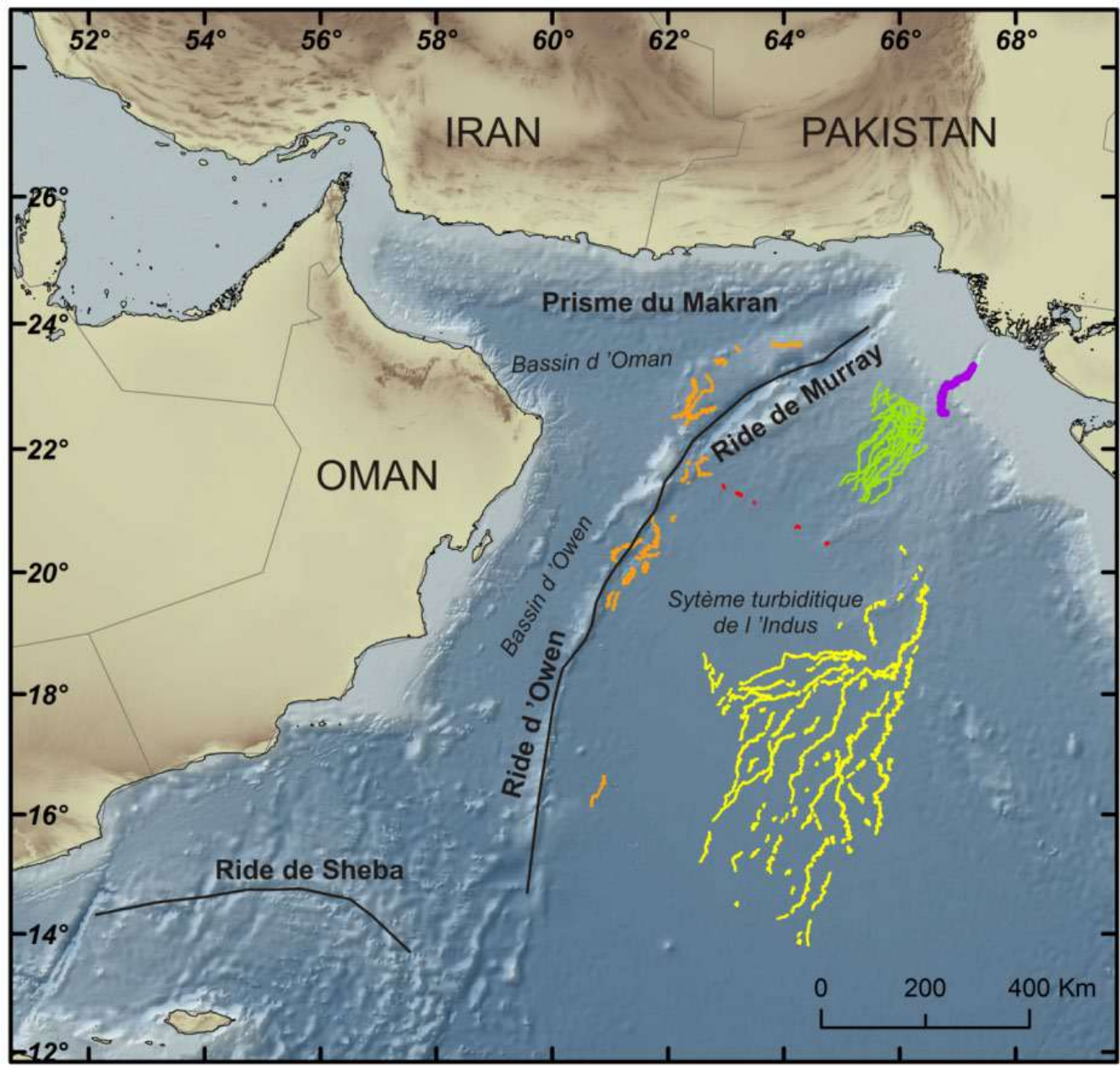


Oligocène - Actuel : ouverture du golfe d'Aden, de la mer Rouge et du rift est-africain



<b>CÉNZOÏQUE</b>	<b>QUATERNAIRE</b>		Ma
	<b>PLIOCÈNE</b>	PLAISANCIEN	1,75
		ZANCLÉIEN	3,4
		MESSINIEN	5,3
	<b>MIOCÈNE</b>	TORTONIEN	7,1
		SERRAVALLIEN	11,0
		LANGHIEN	14,7
		BURDIGALIEN	15,8
		AQUITANIEN	20,3
	<b>OLIGOCÈNE</b>	CHATTIEN	23,0
		RUPÉLIEN	28
		PRIABONIEN	33,7
	<b>ÉOCÈNE</b>	BARTONIEN	37,0
		LUTÉTIEN	40
YPRESIEN		46,0	
THANÉTIEN		53	
<b>PALÉOCÈNE</b>	DANIEN	59	
<b>MÉSOZOÏQUE</b>	<b>CRÉTACÉ</b>	MAASTRICHTIEN	65,0
		CAMPANIEN	72,0
		SANTONIEN	83
		CONIACIEN	87
		TURONIEN	88
	<b>INFÉRIEUR</b>	CÉNOMANIEN	92
		ALBIEN	96
		APTIEN	108
		BARRÉMIEN	113
		HAUTERIVIEN	117
	<b>SUPÉRIEUR (MALM)</b>	VALANGINIEN	123
		BERRIASIEN	131
		TITHONIEN	135
		KIMMÉRIDGIEN	141
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<b>INFÉRIEUR (LIAS)</b>	TOARCIEN	175	
	PLIENSBACHIEN	184	
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<b>TRIAS</b>	HETTANGIEN	200	
	RHÉTIEN	203	
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<b>MOYEN</b>	ANISIEN	240	
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<b>INFÉRIEUR</b>	INDUSIEN	250	



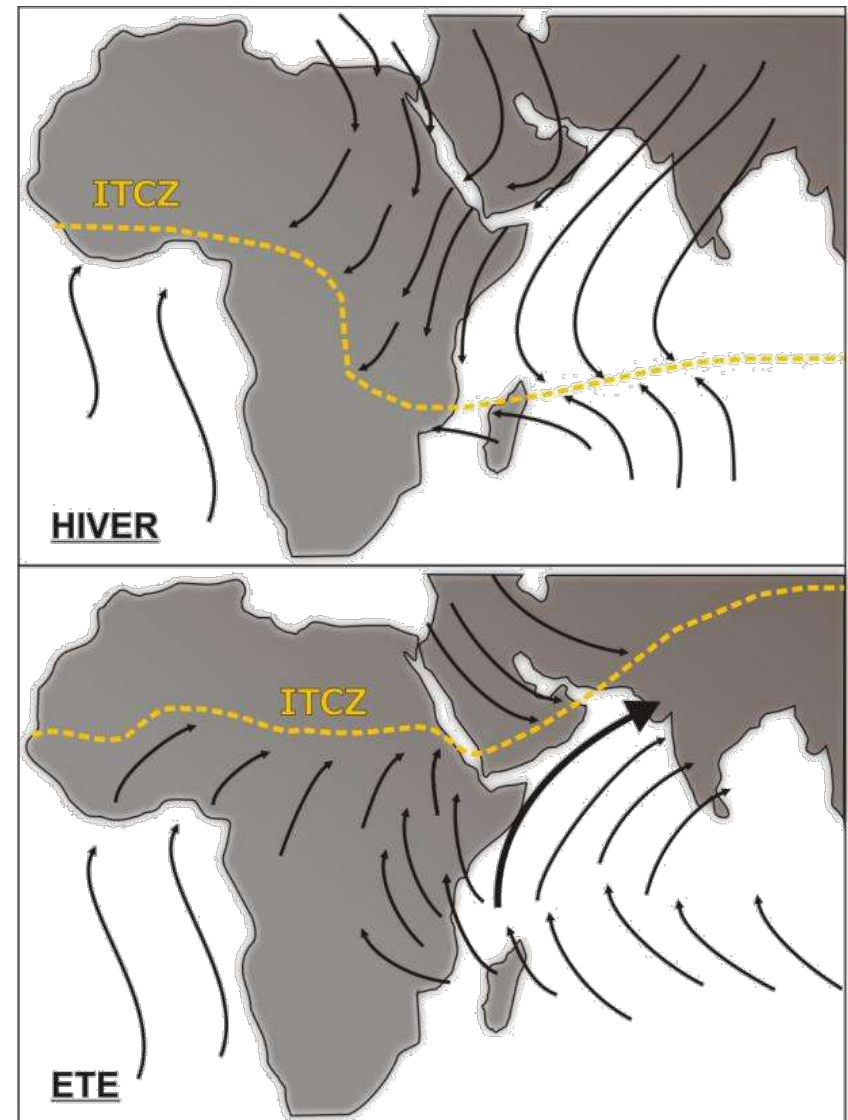


Bourget et al. 2013





- Climat aride
- Précipitations saisonnières (mousson indienne)

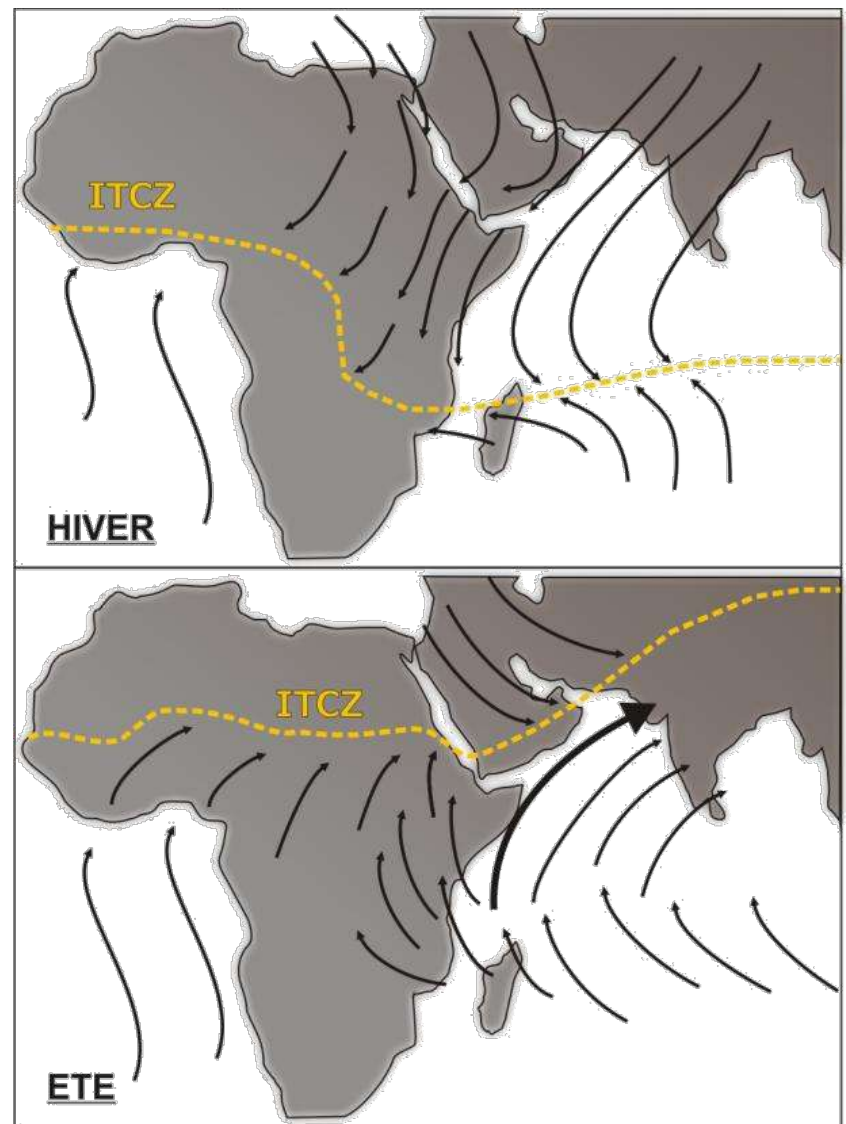


Fleitmann et al. 2007

**Variation d'intensité de la mousson  
(cycle de précession ~ 23 ka)**

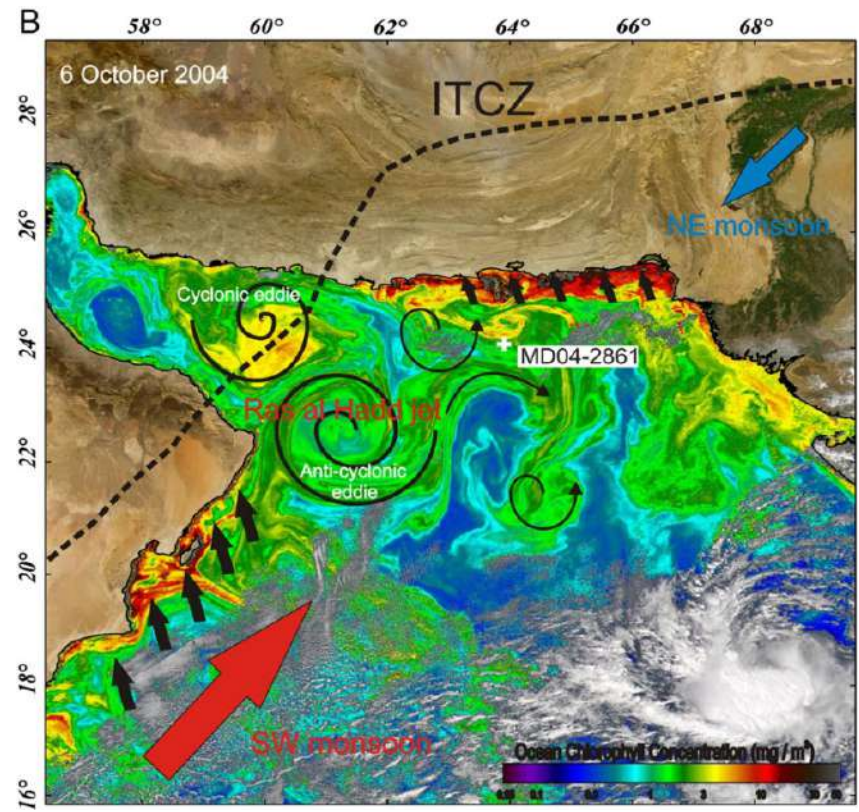
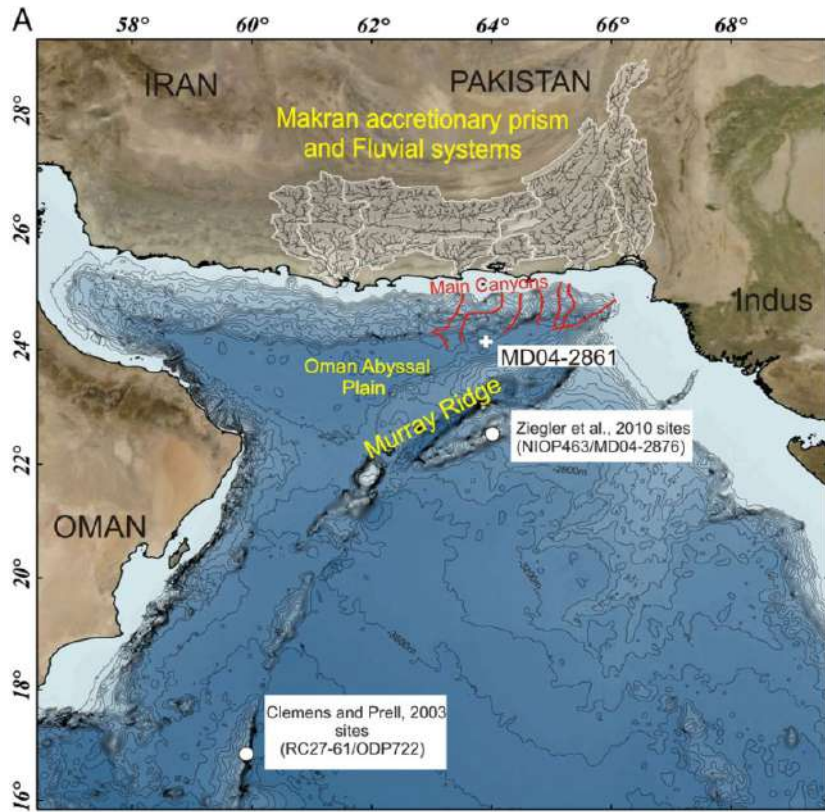


**Alternance de phases arides /  
humides au cours des derniers  
25 000 ans BP**

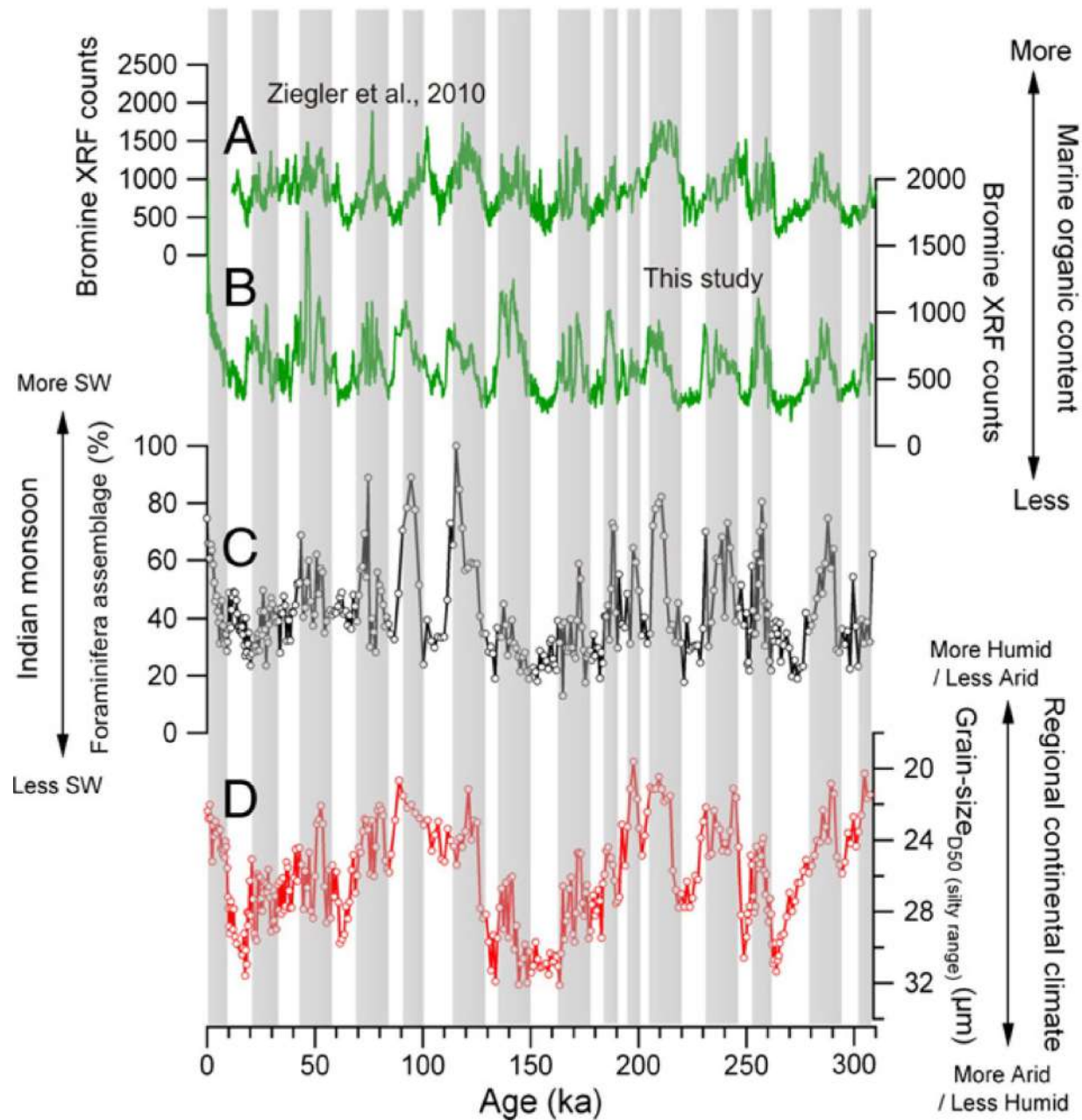


Fleitmann et al. 2007



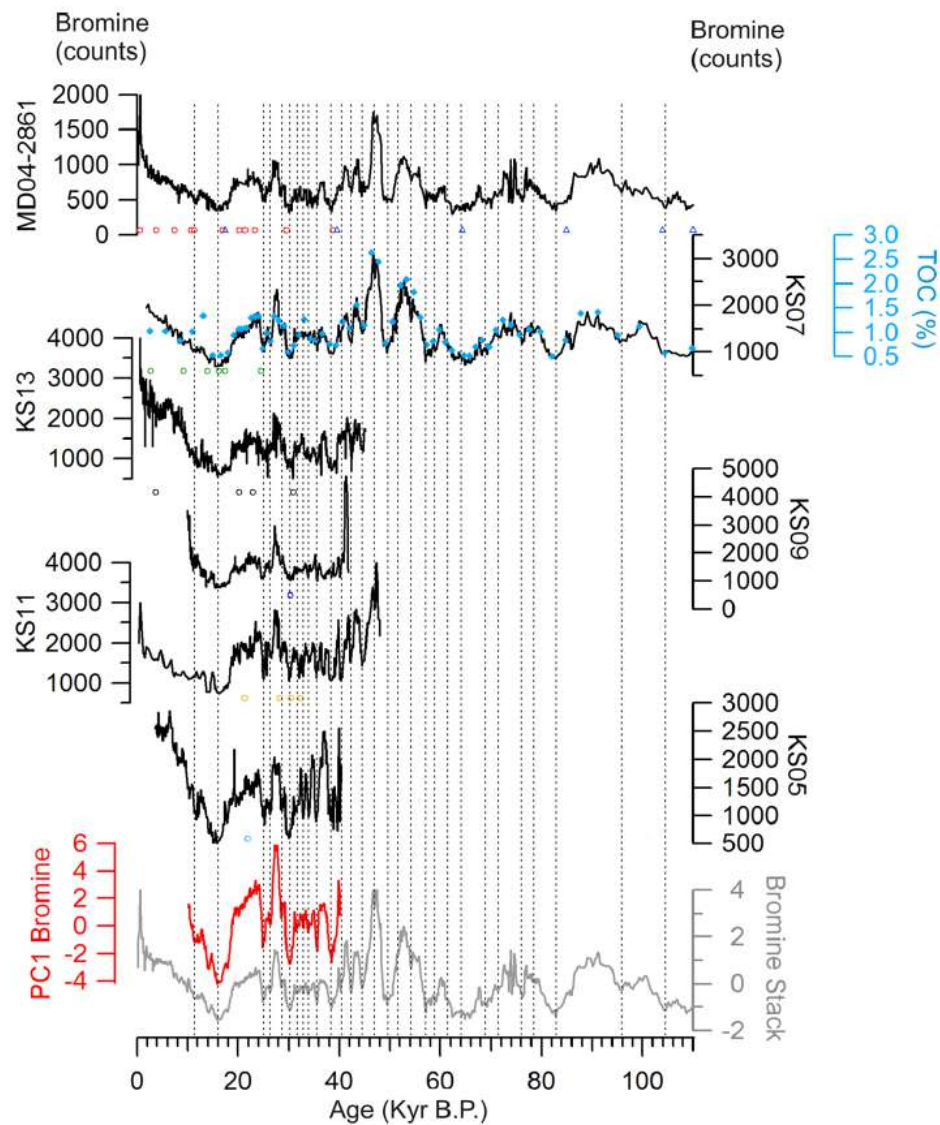
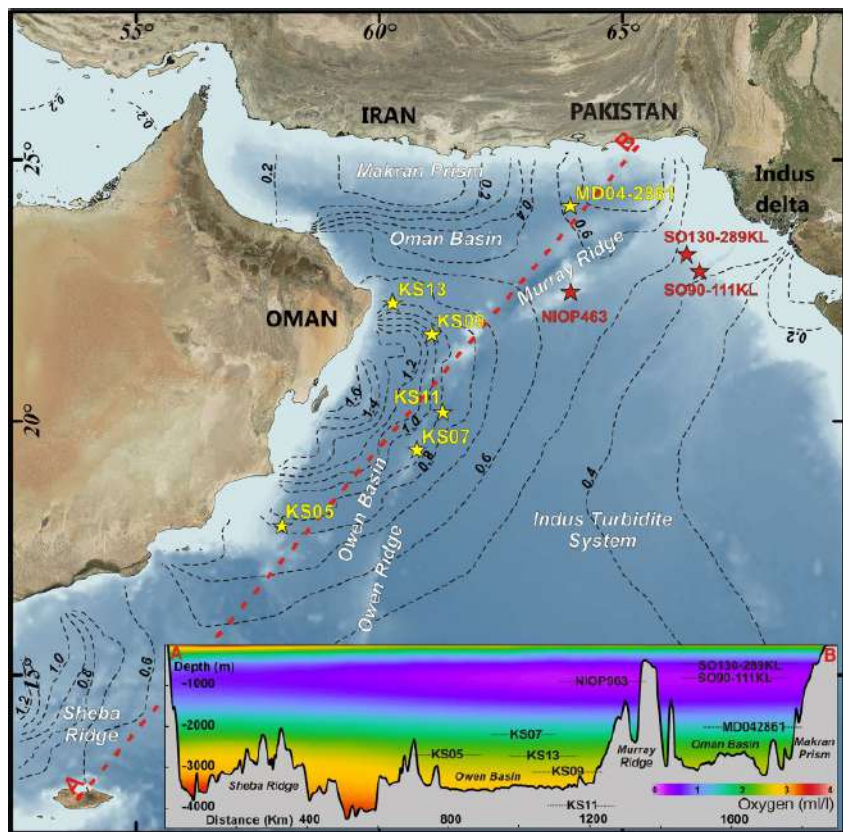


Caley et al. 2011



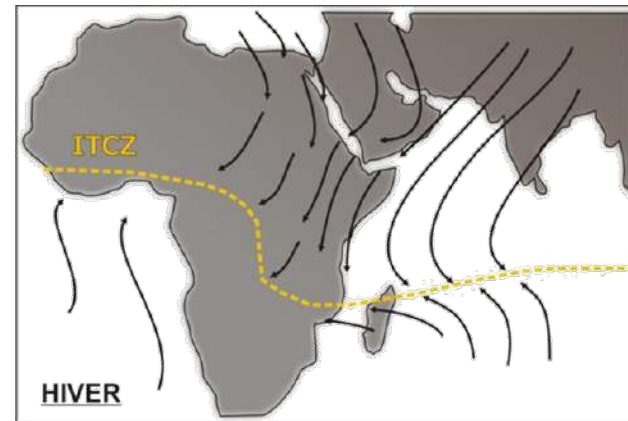
Caley et al. 2011



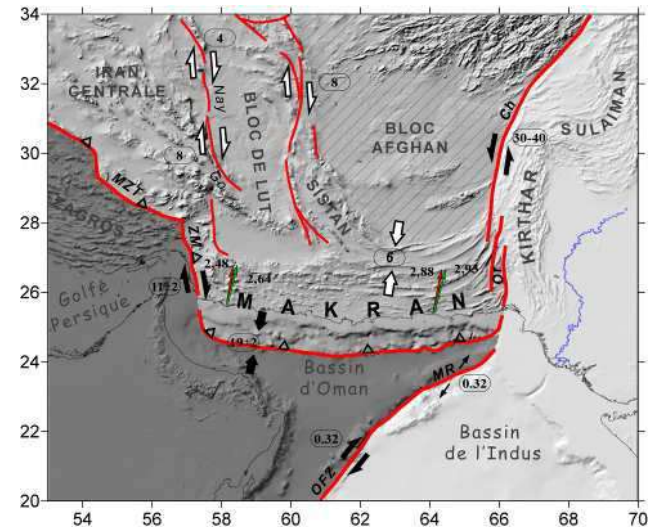


Caley et al. 2011

Un contexte climatique riche

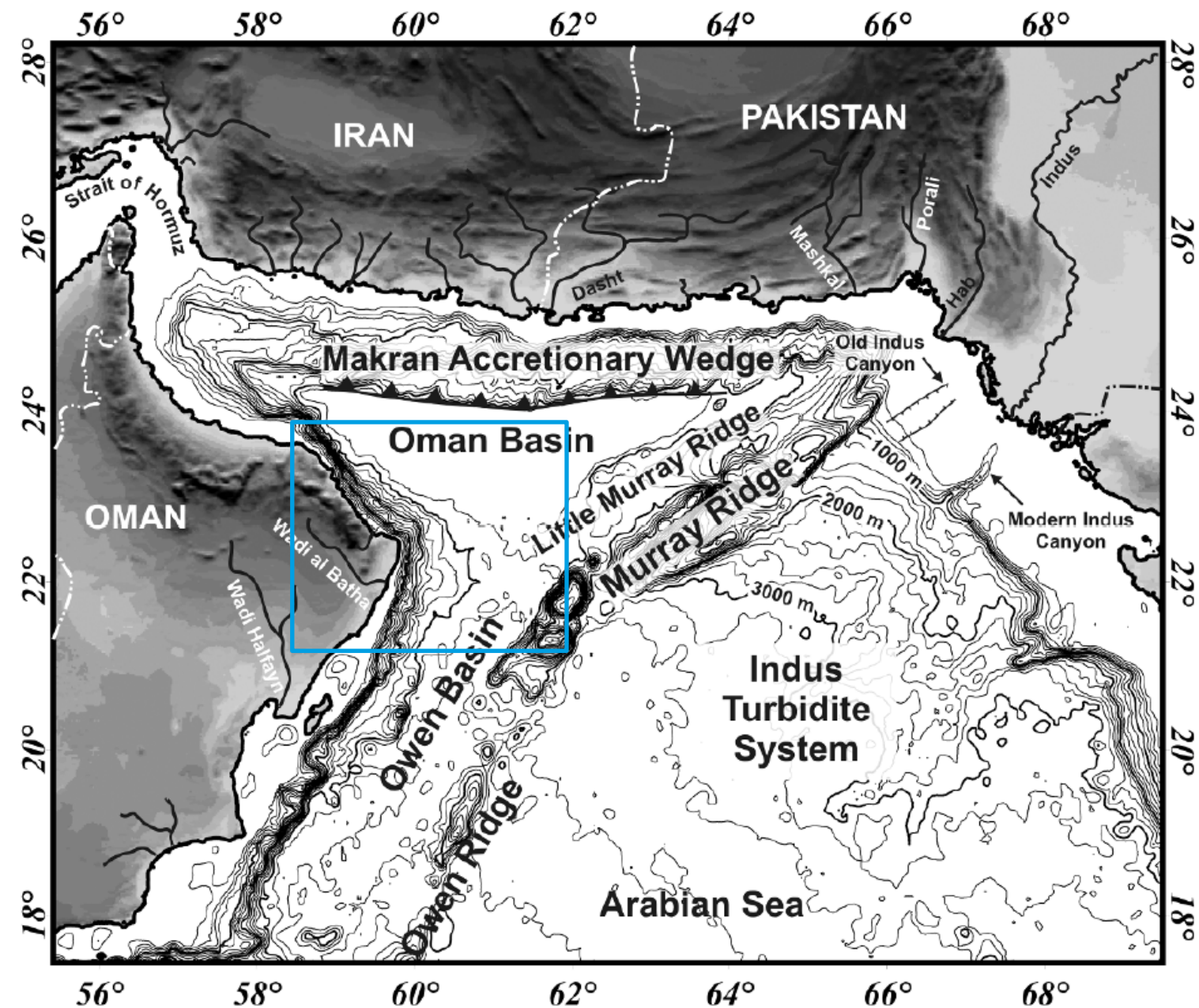


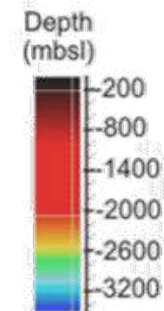
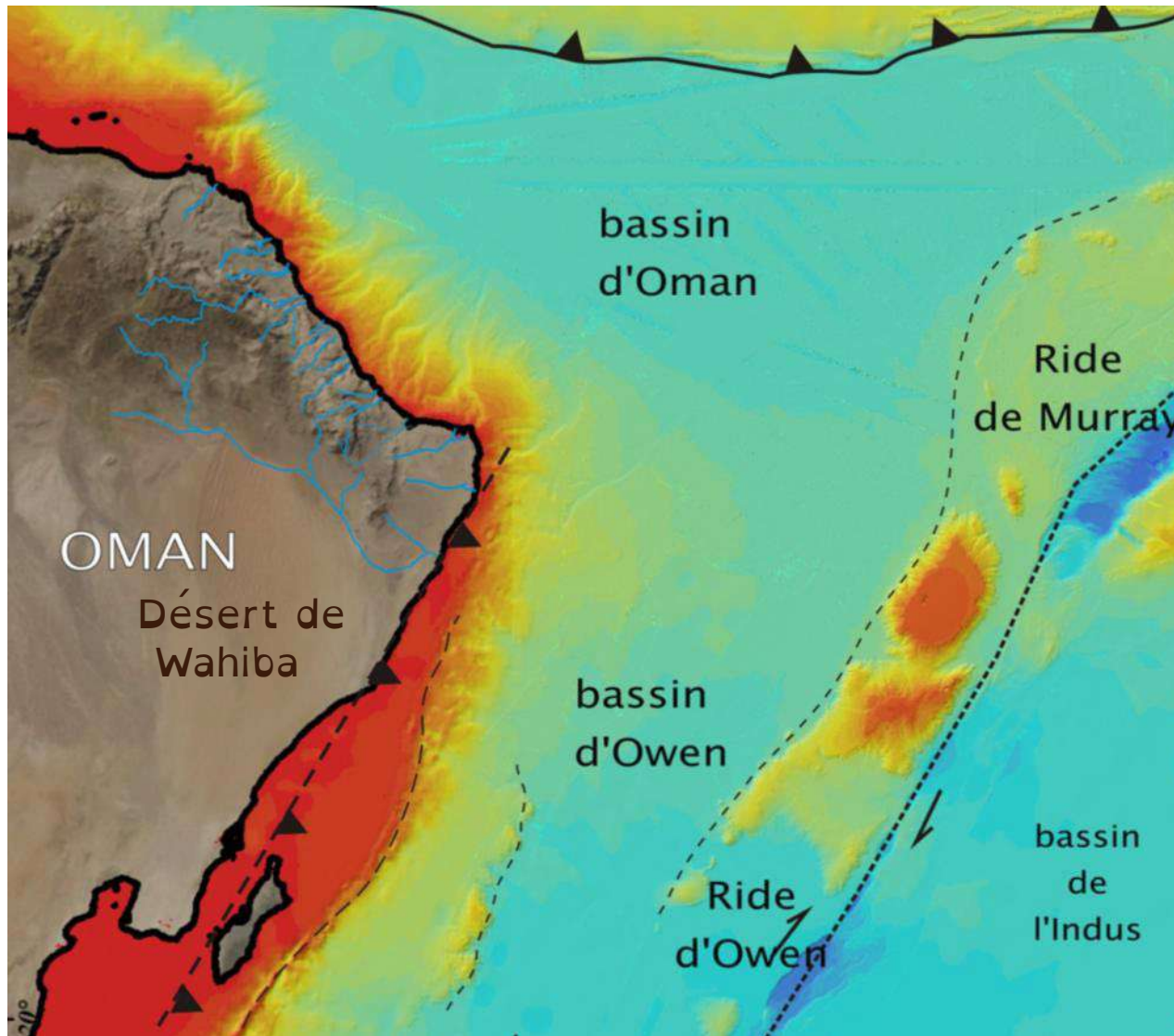
Une histoire tectonique riche



Influences de ces forçages sur la sédimentation profonde ?

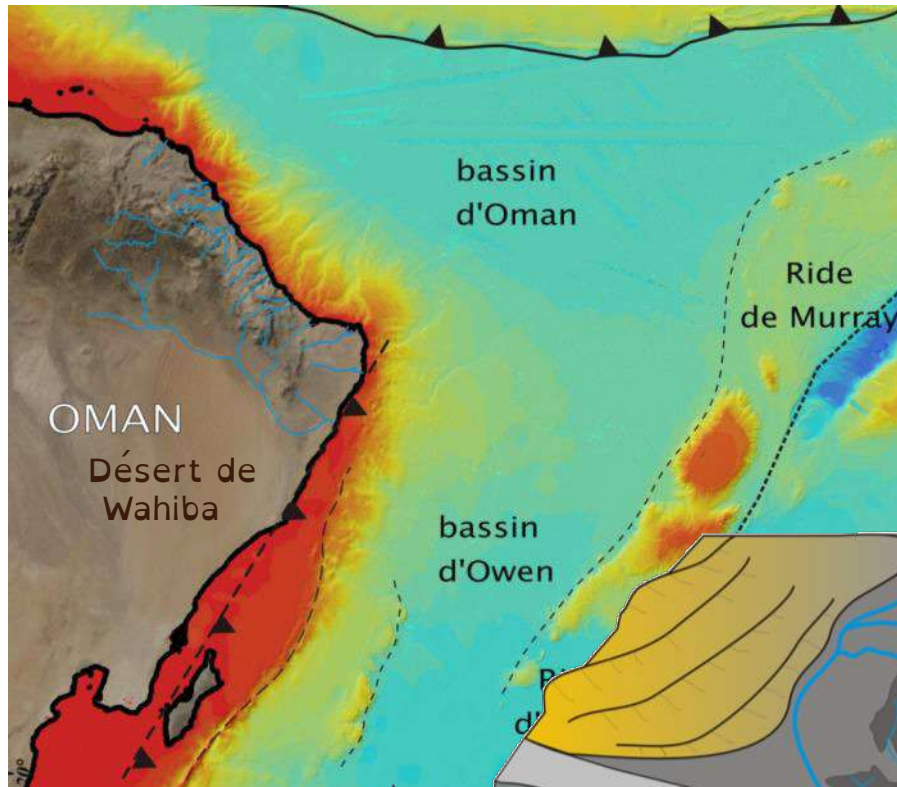




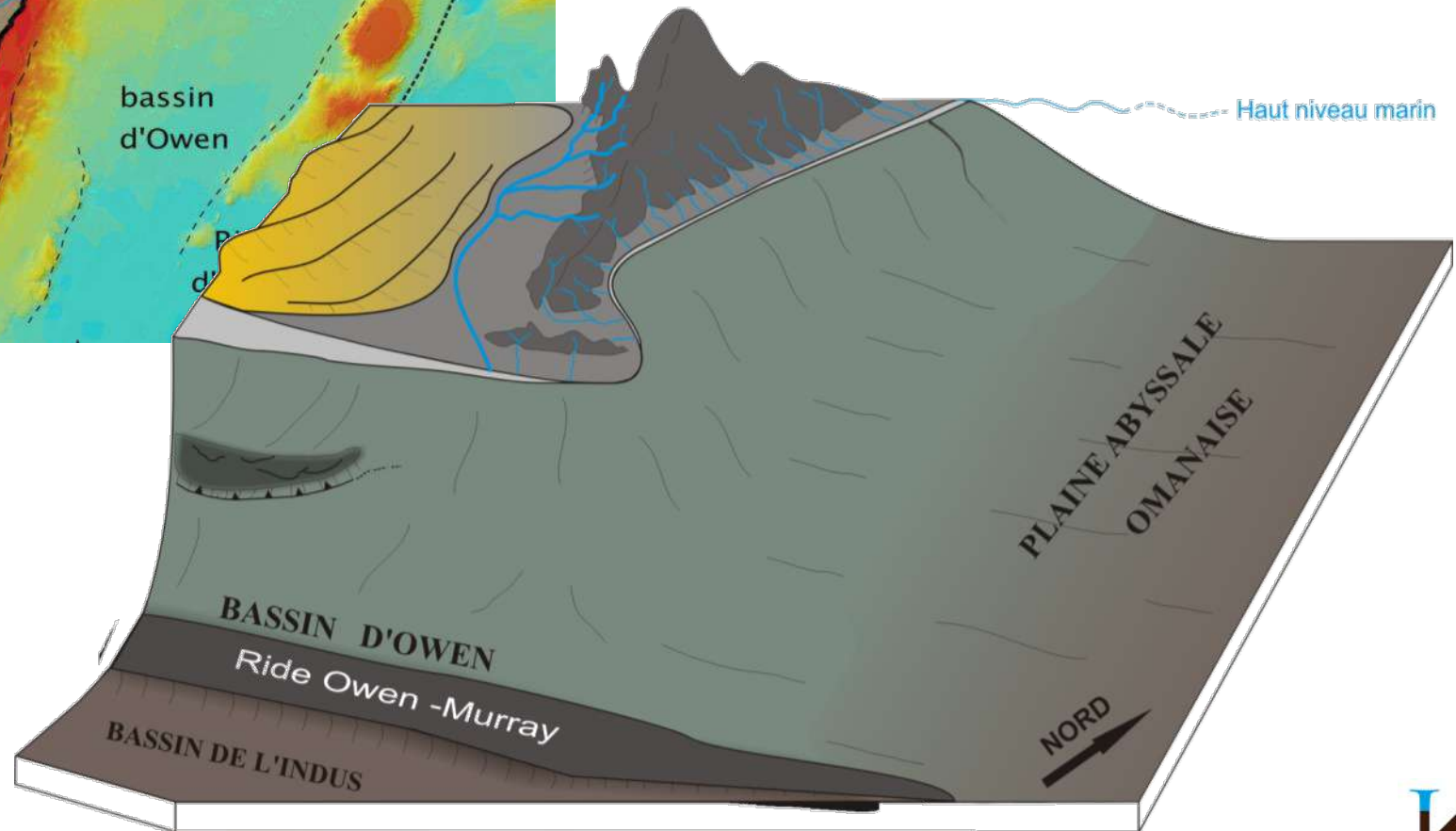


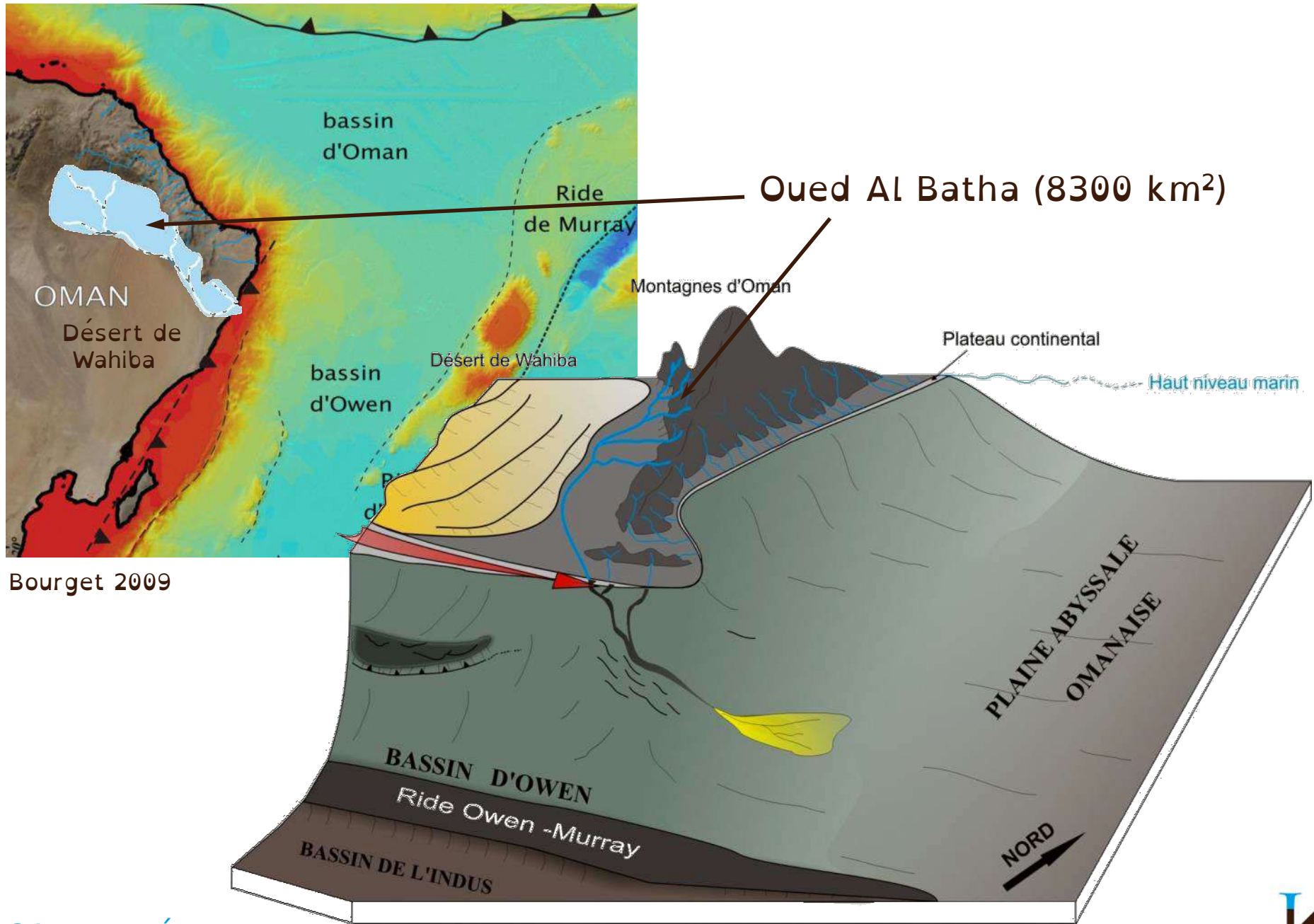
Bourget 2009



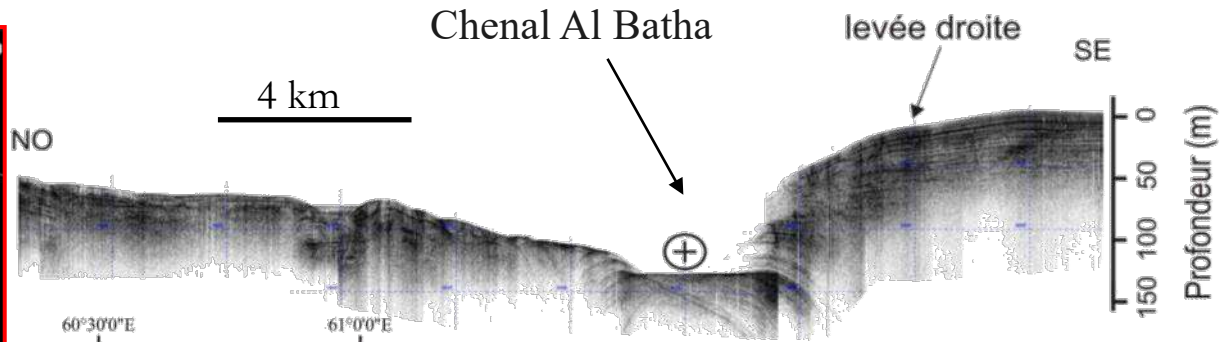
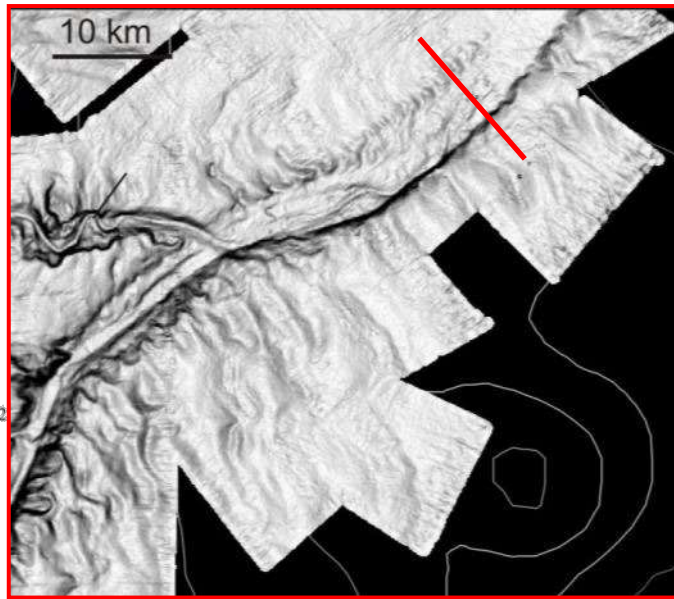


Bourget 2009

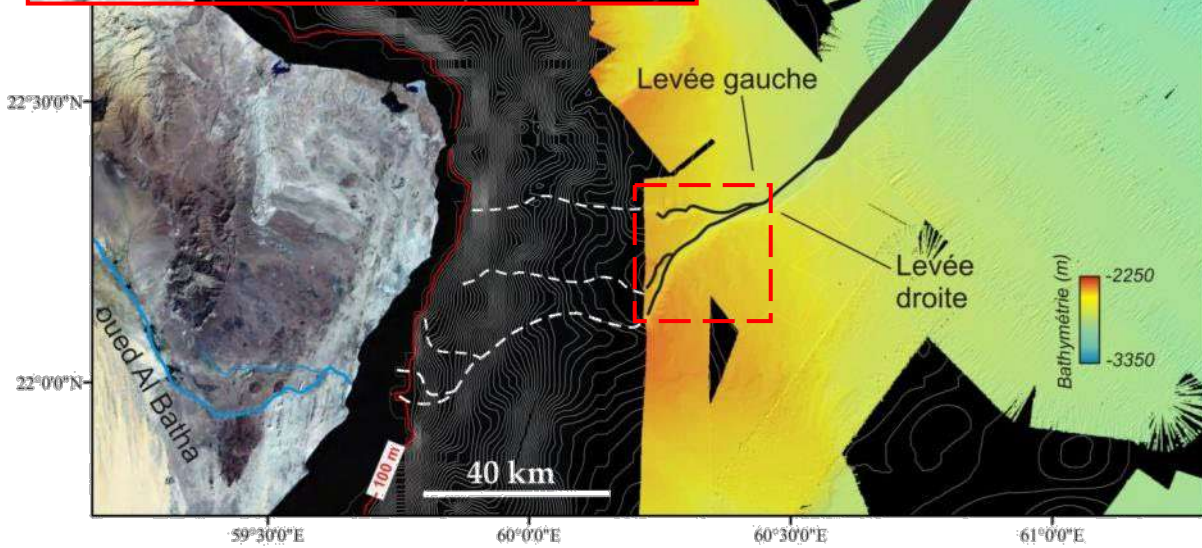


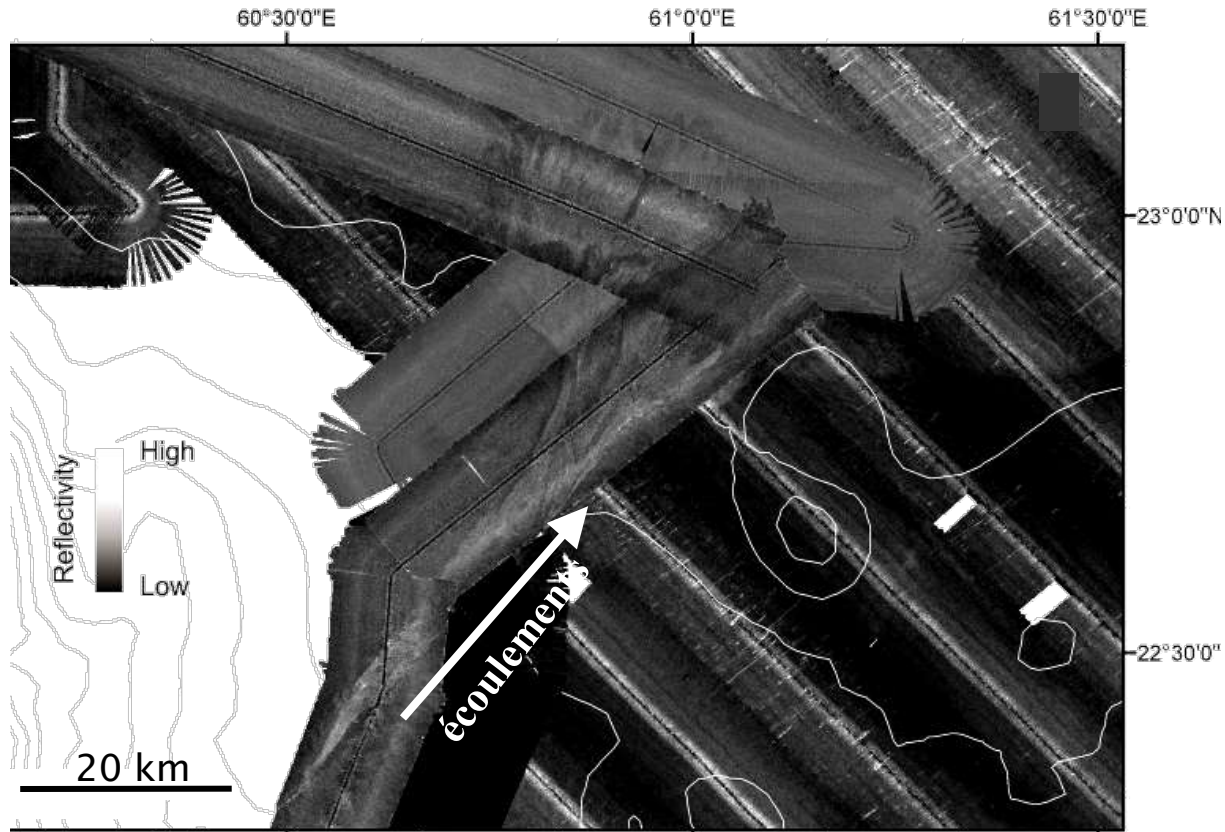






Bourget et al 2011



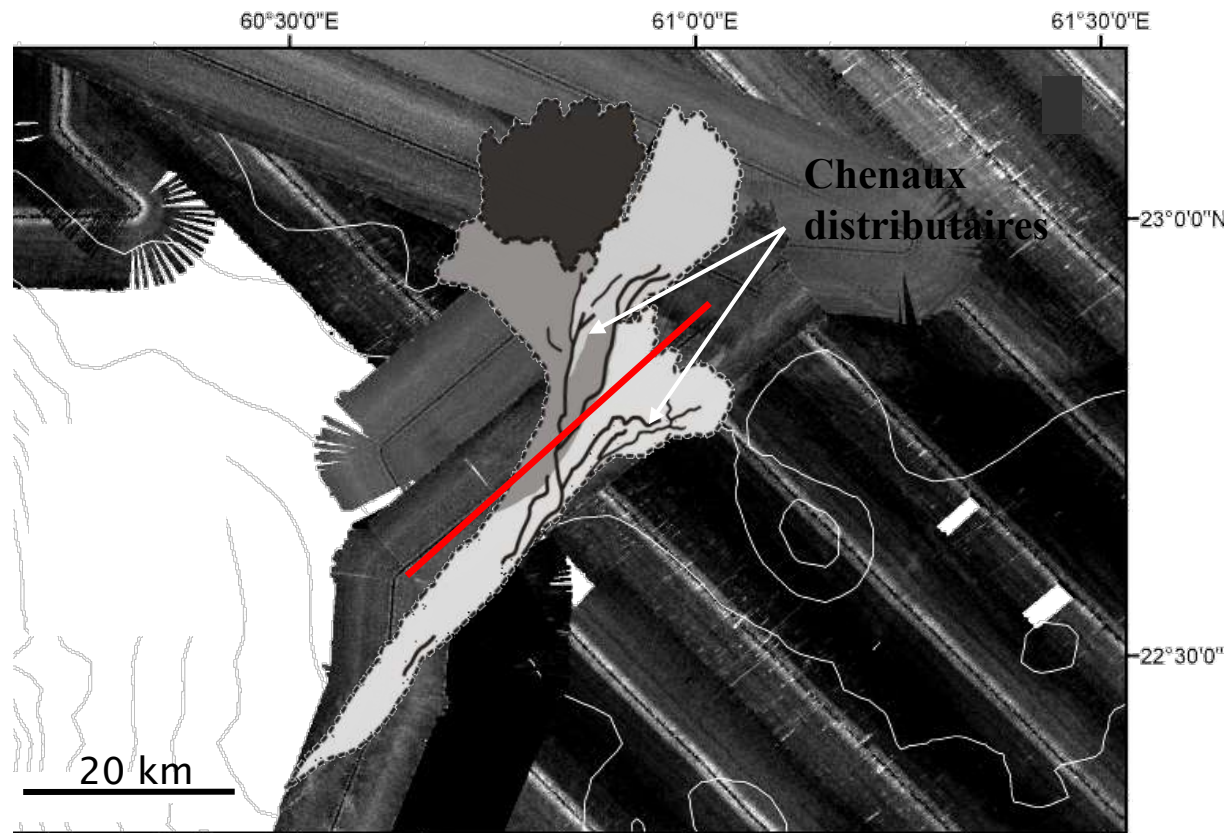


Bourget 2009

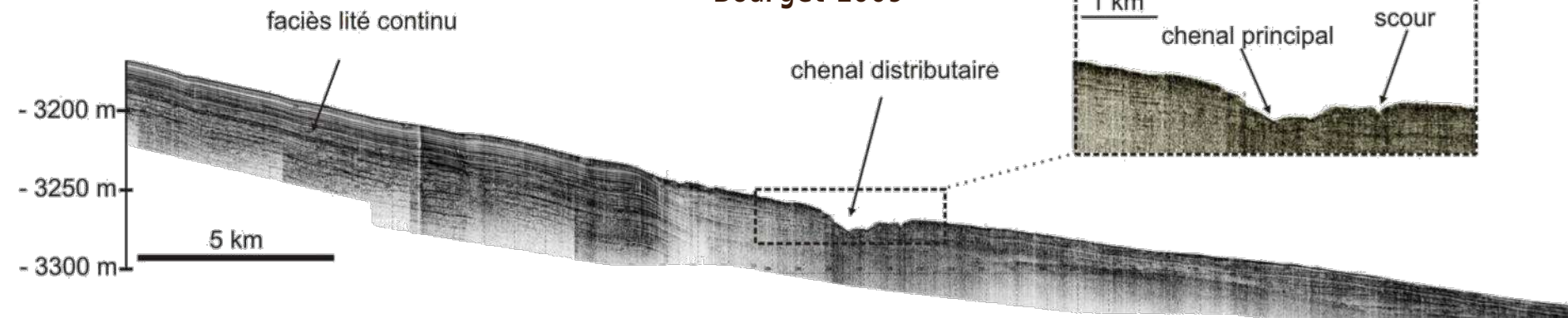
## Lobe Al Batha (~ 1000 km<sup>2</sup>)

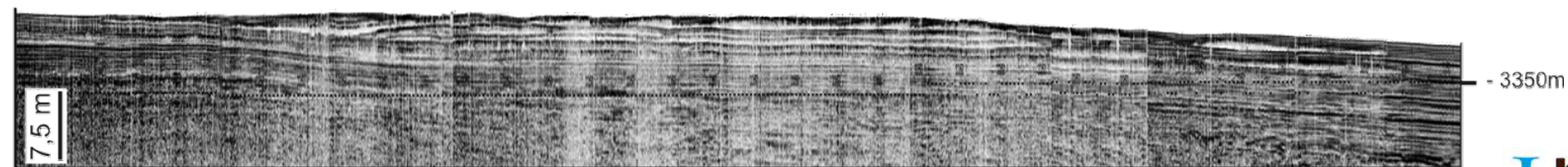
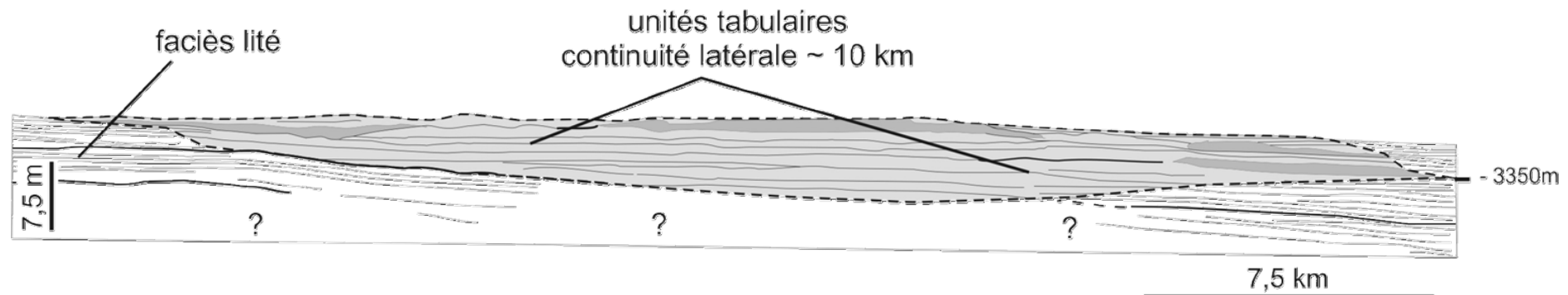
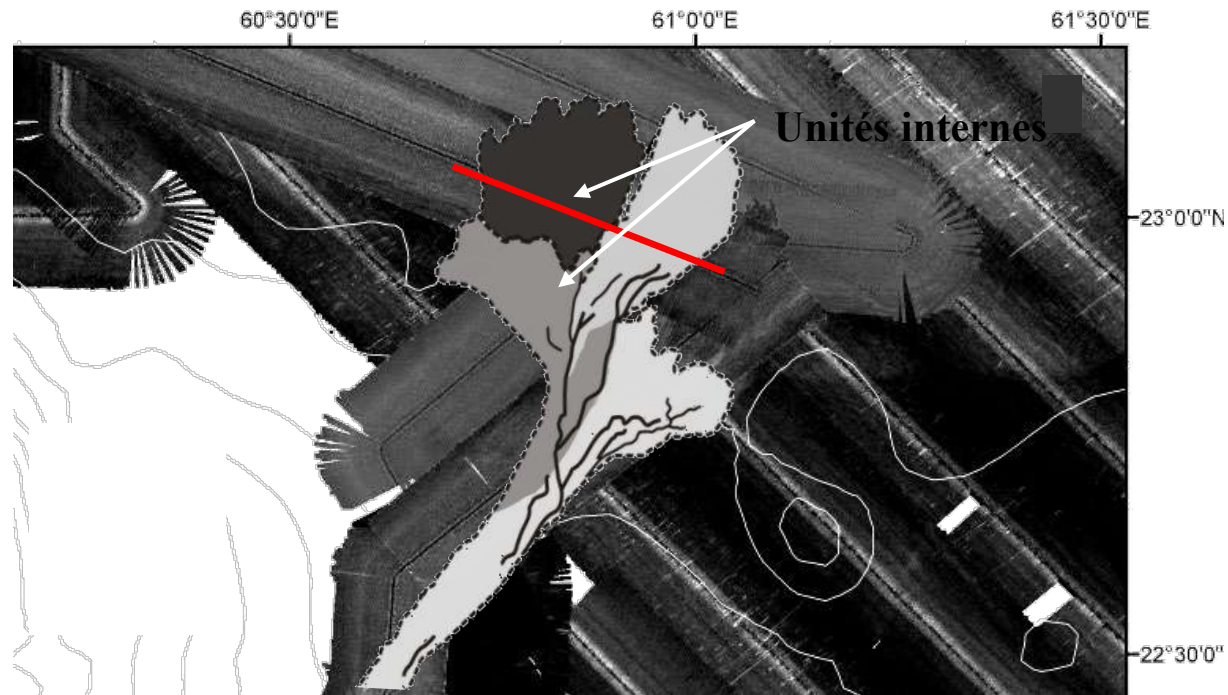
J. Bourget, S. Zaragosi, T. Mulder, J.-L. Schneider, T. Garlan, A. Van Toer, V. Mas, N. Ellouz-Zimmermann. (2010) Hyperpycnal-fed turbidite lobe architecture and recent sedimentary processes: A case study from the Al Batha turbidite system, Oman margin *Sedimentary Geology* 229(3), 144-159.



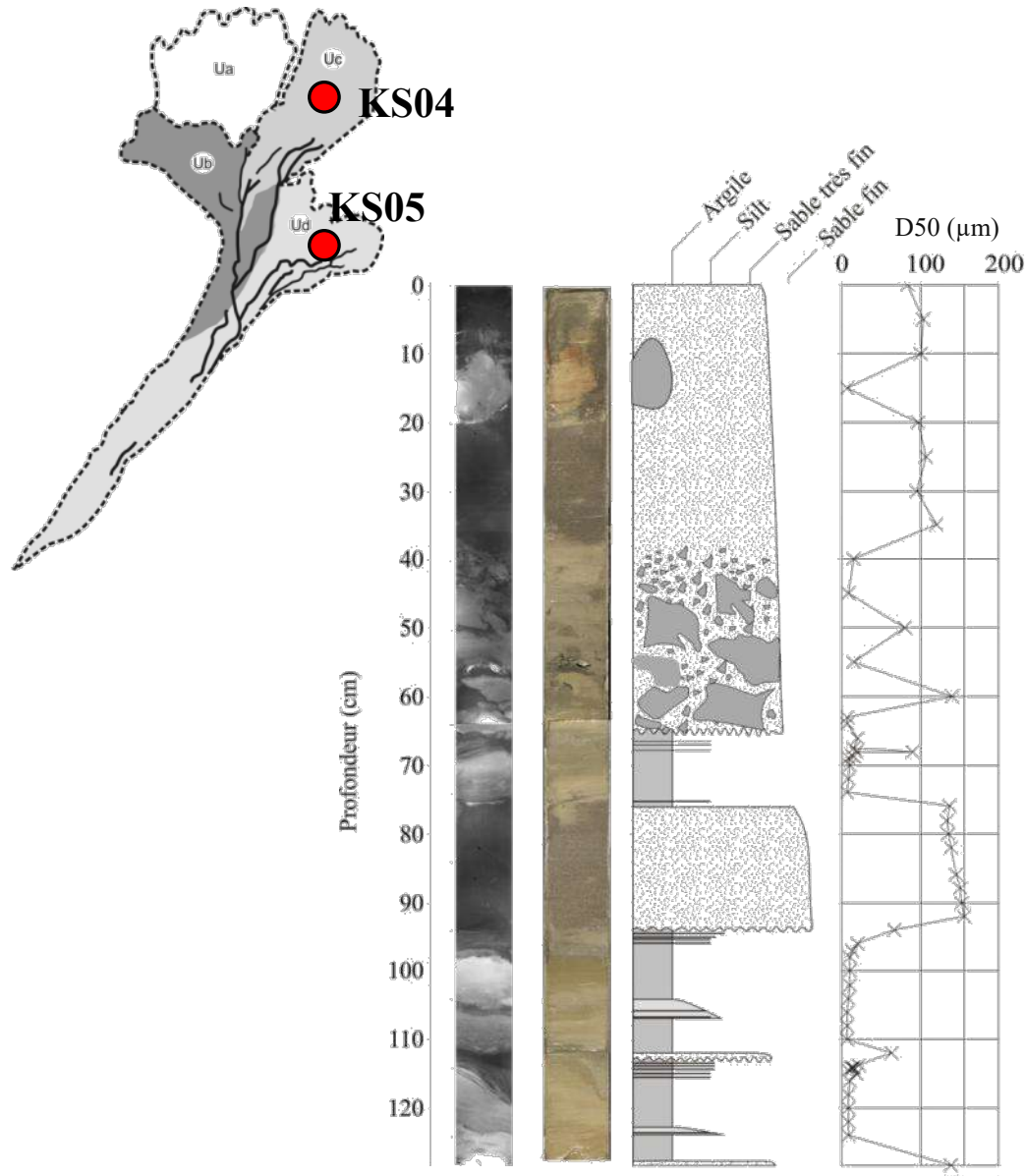


Bourget 2009

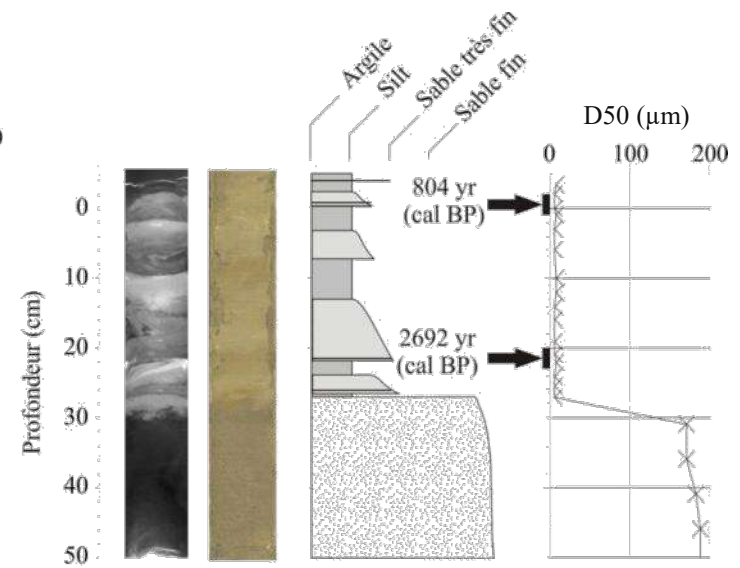






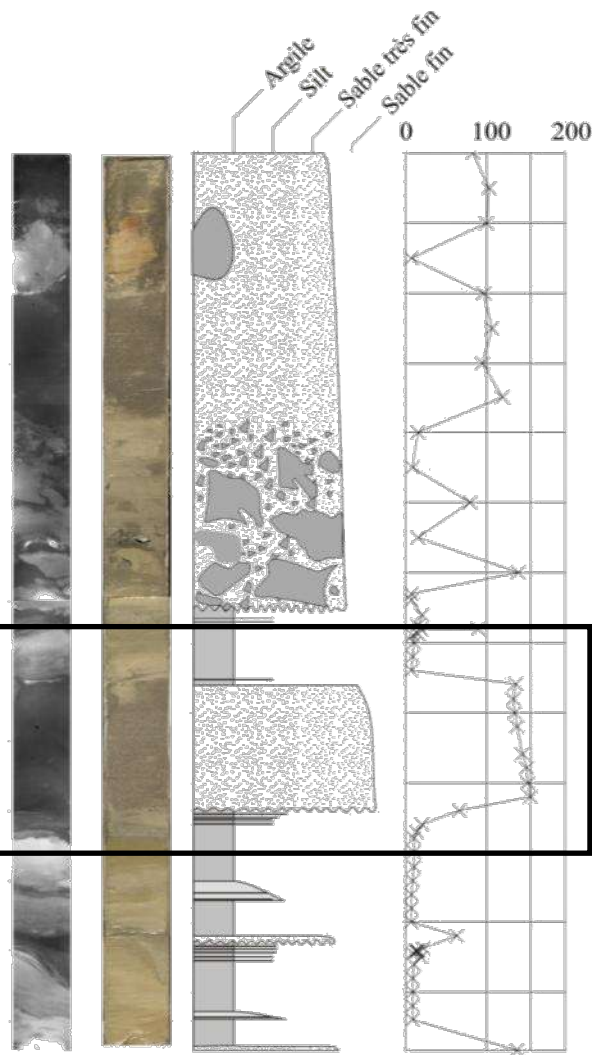
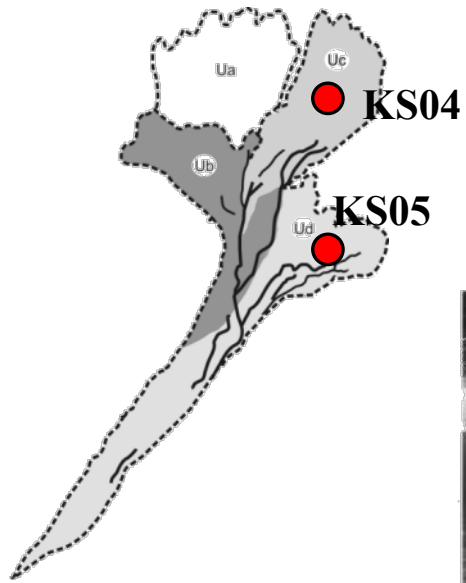


KS04

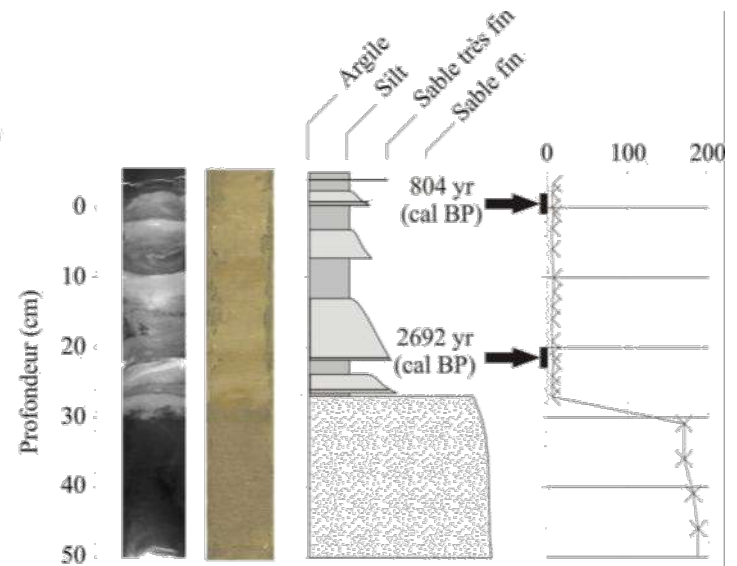


KS05

Bourget et al. 2011

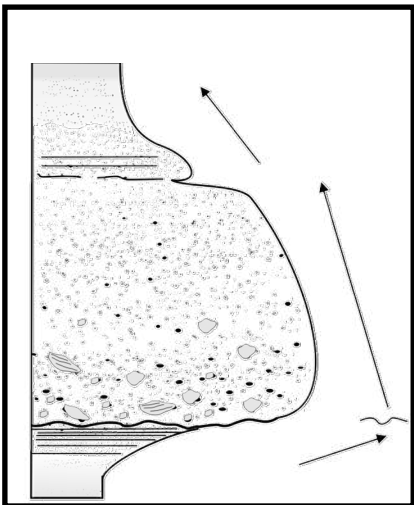


KS04

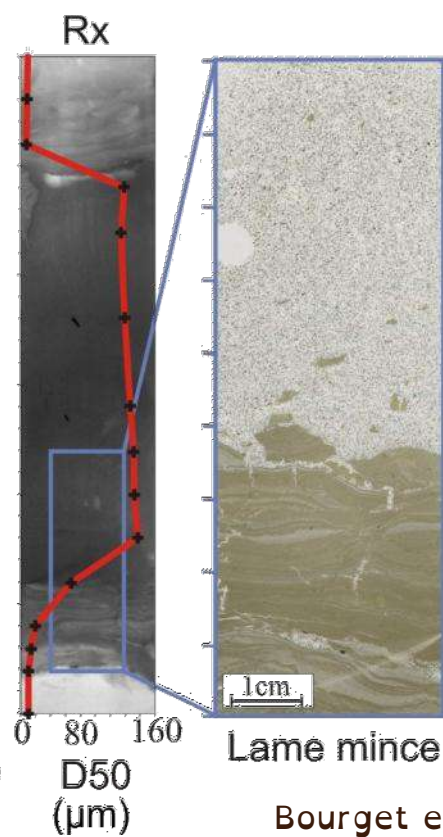
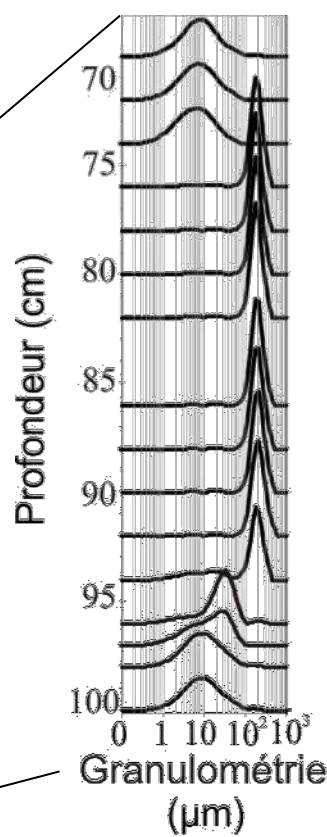
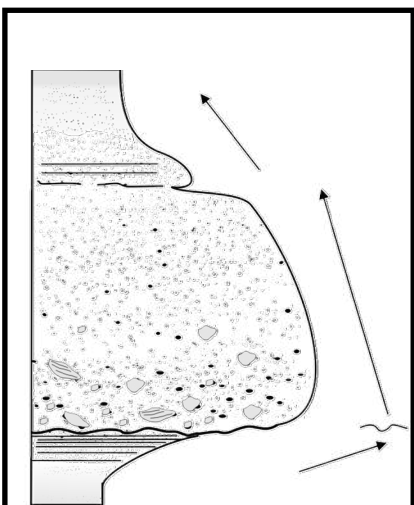
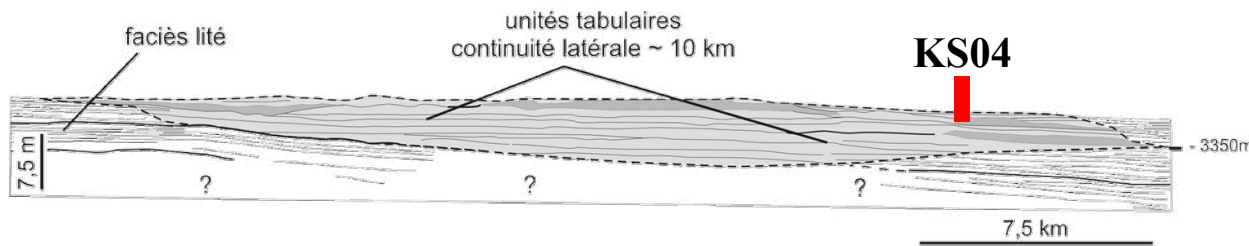
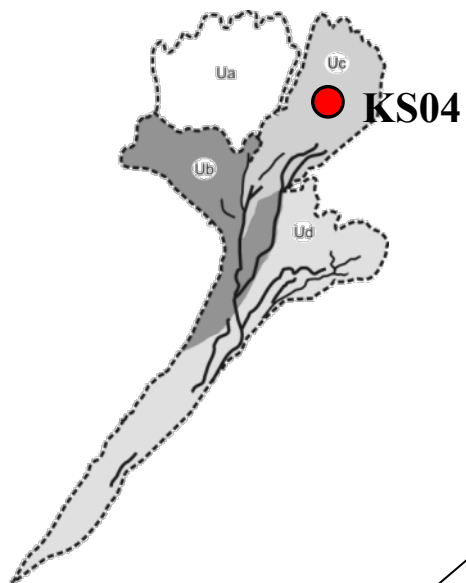


KS05

Bourget et al. 2011





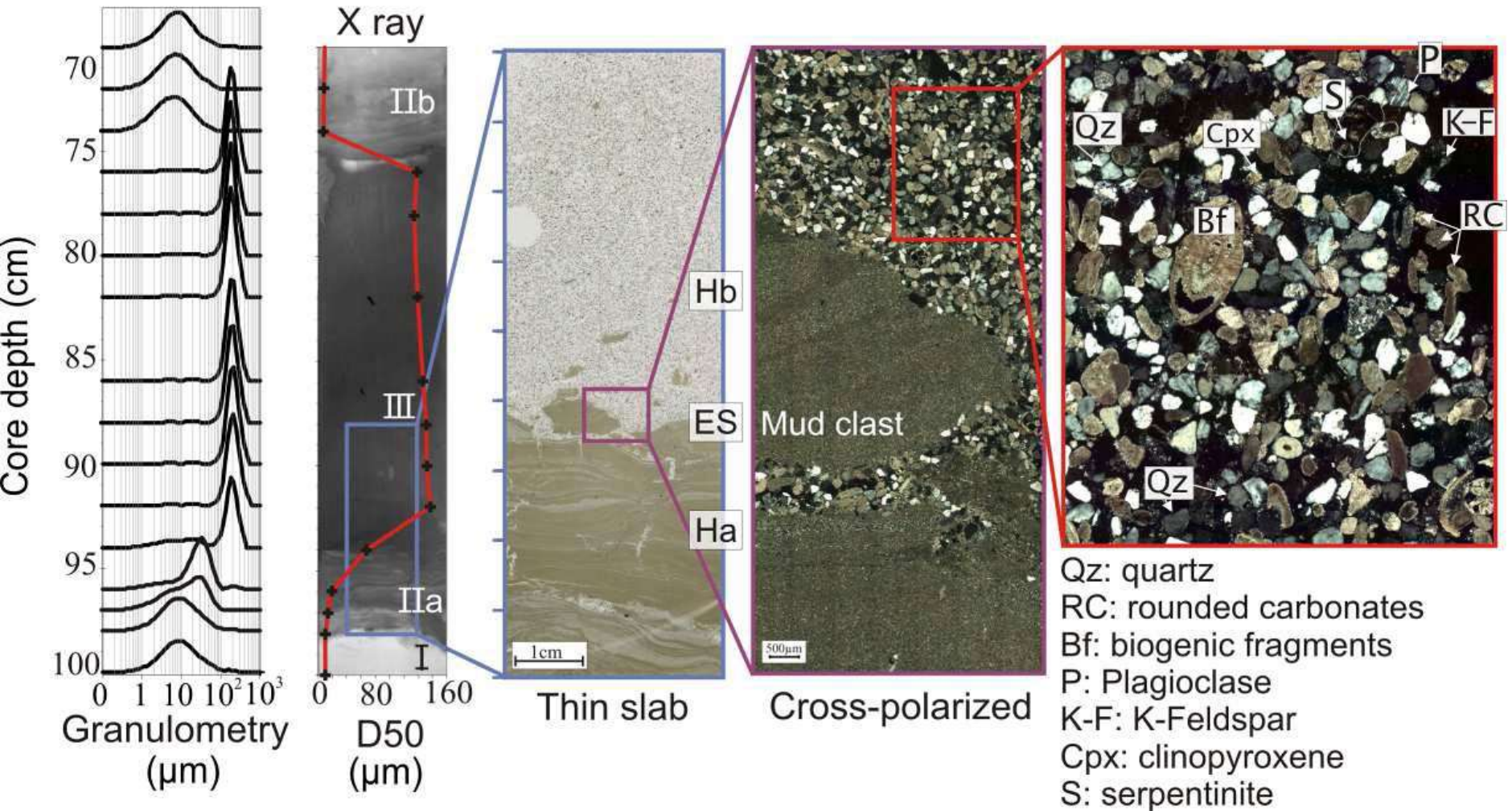


Bourget et al. 2011

## Hyperpycnites: alimentation du lobe lors des crues de l'oued Al Batha



# MARABIE KS04 89 - 99cm



Bourget 2009

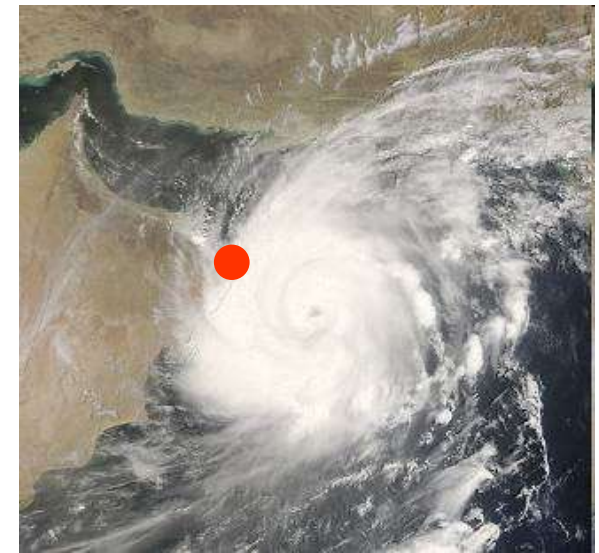




Bourget 2009



**Hyperpycnites : alimentation du lobe lors des crues de l'oued Al Batha**



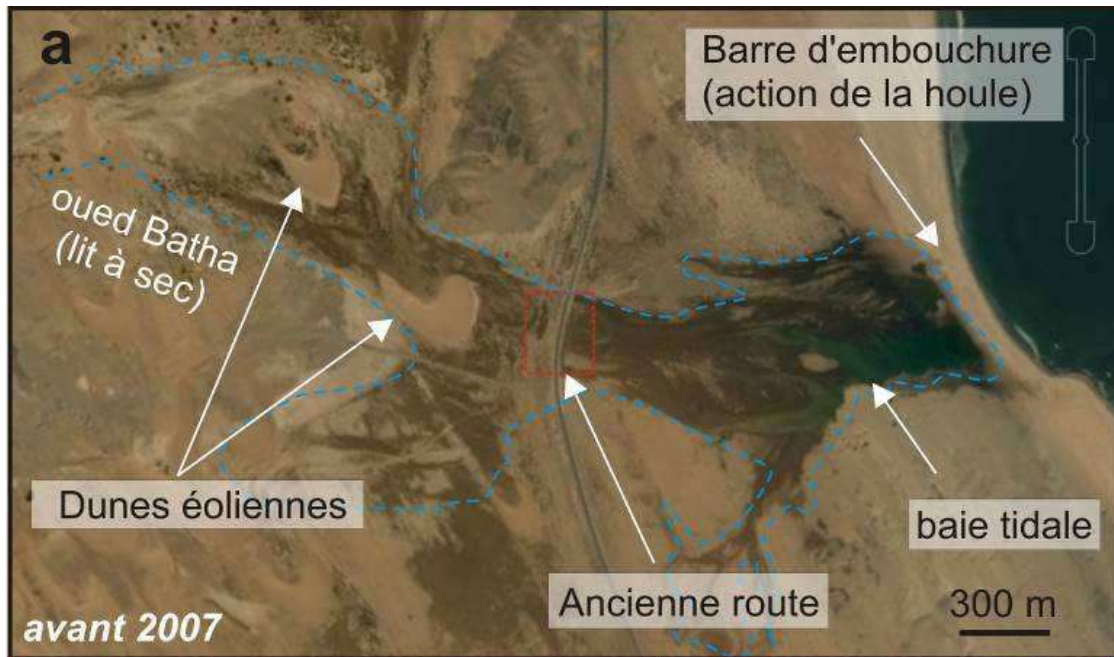
06/06/2007

Source – Nasa Visible Earth

## Le cyclone Gonu

Alimentation du système profond lors d'événements climatiques majeurs (mousson) ?





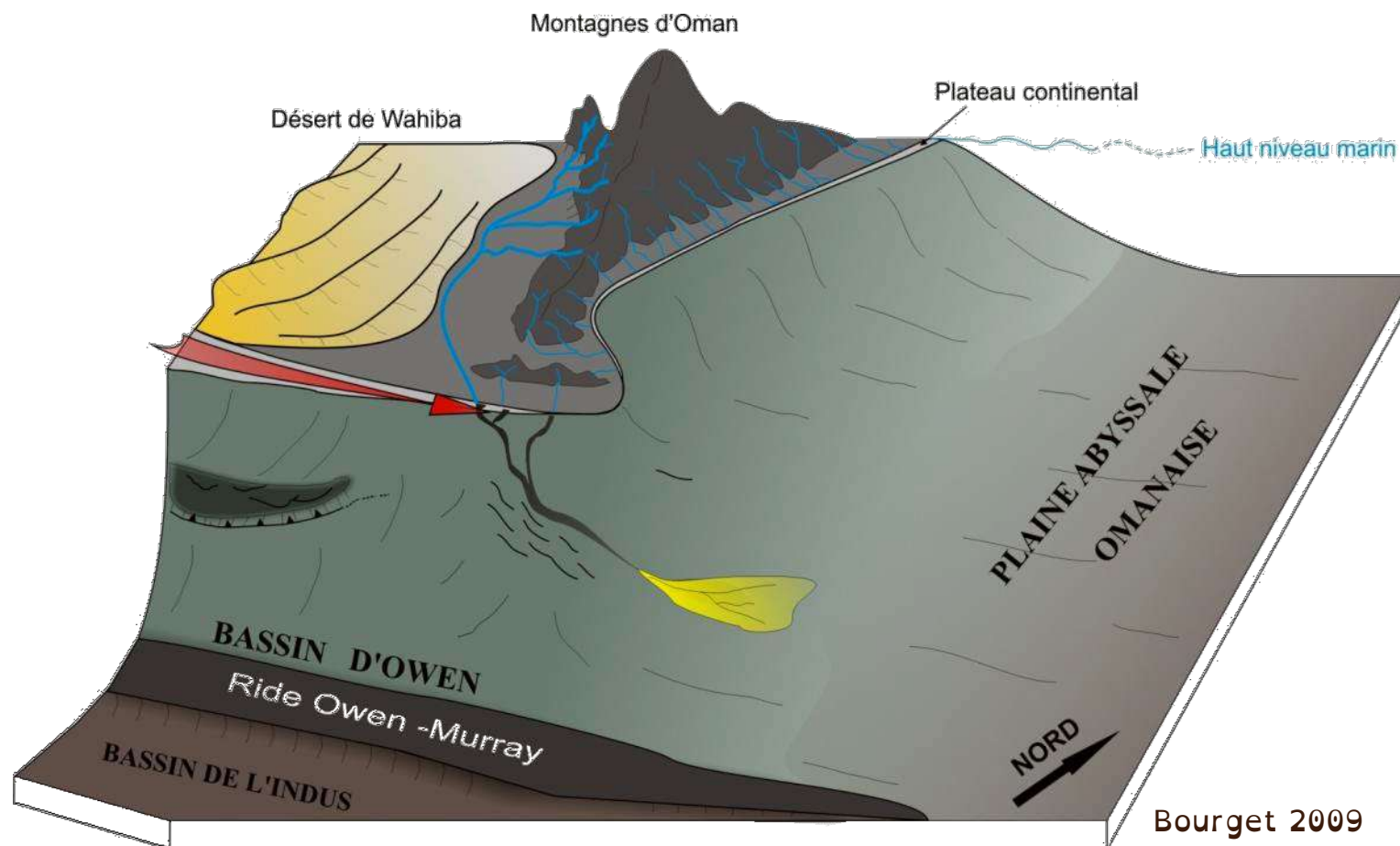
Bourget 2009



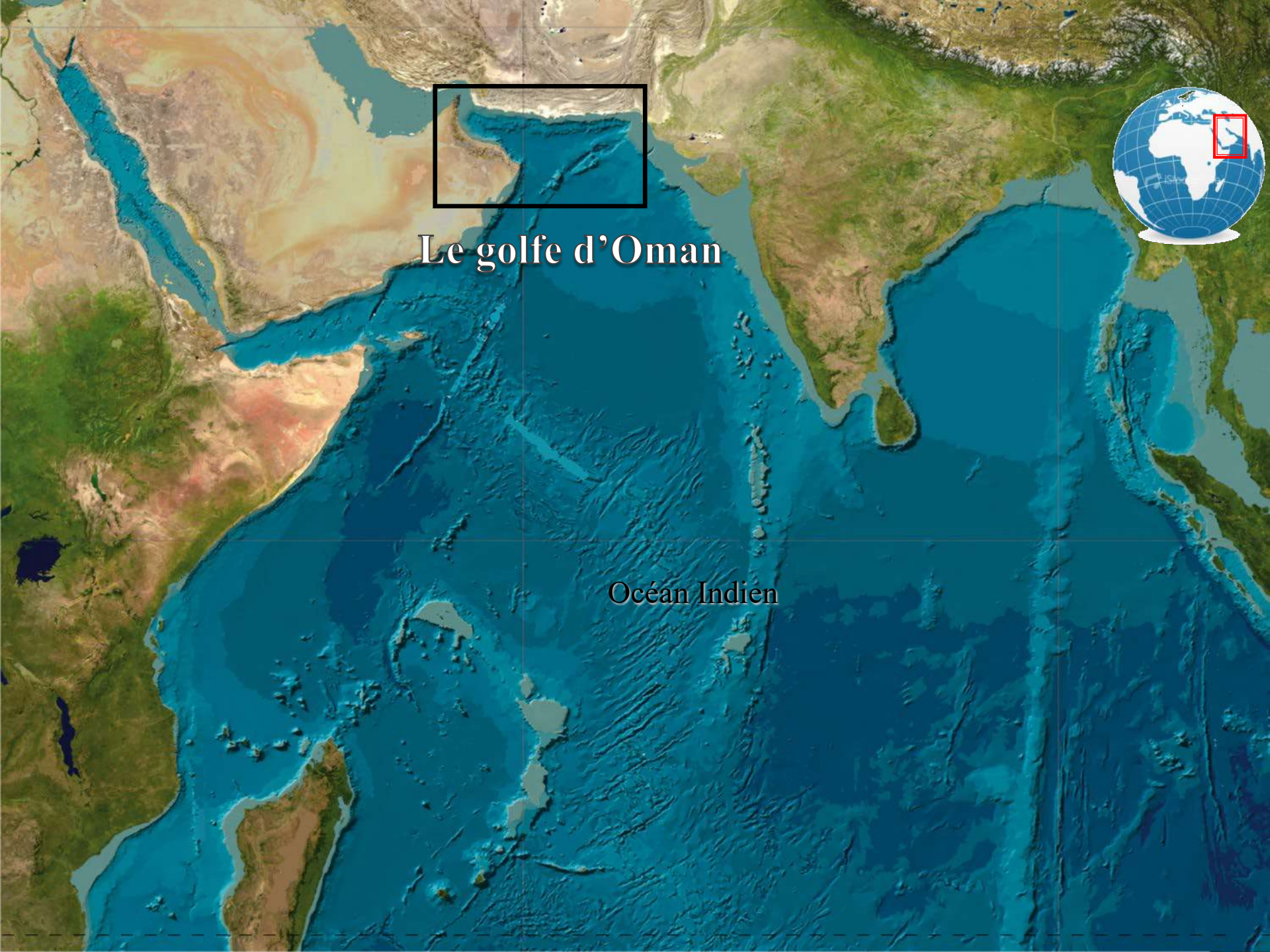


## CONTEXTE HYDROCLIMATIQUE LOCAL (MOUSSON)

## ARCHITECTURE CLASSIQUE - PROFIL TOPOGRAPHIQUE REGULIER



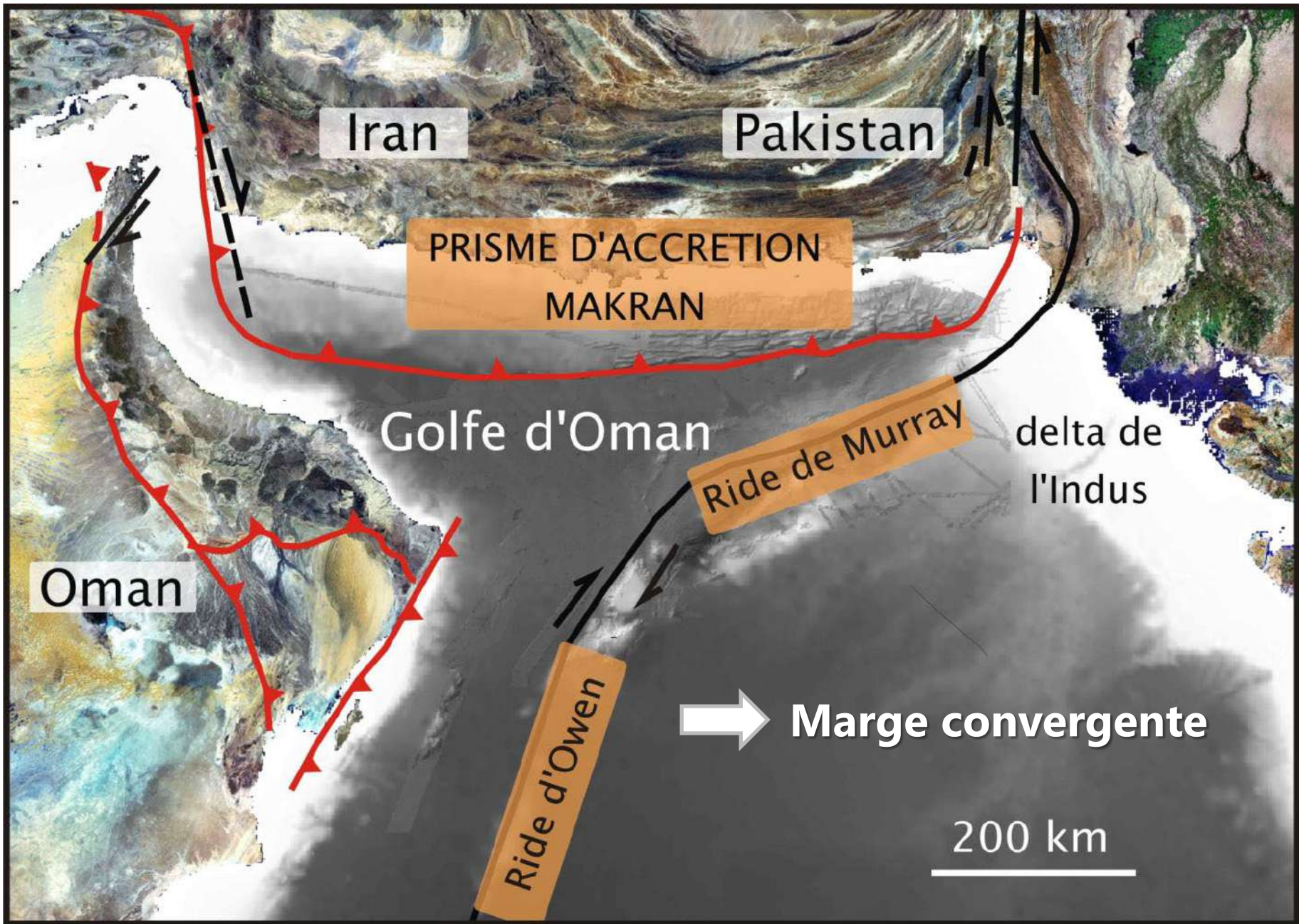
Bourget 2009



Le golfe d'Oman

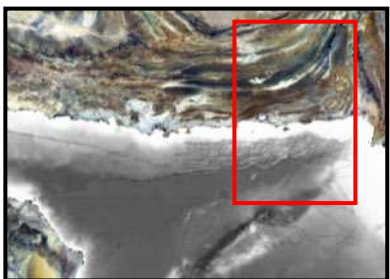
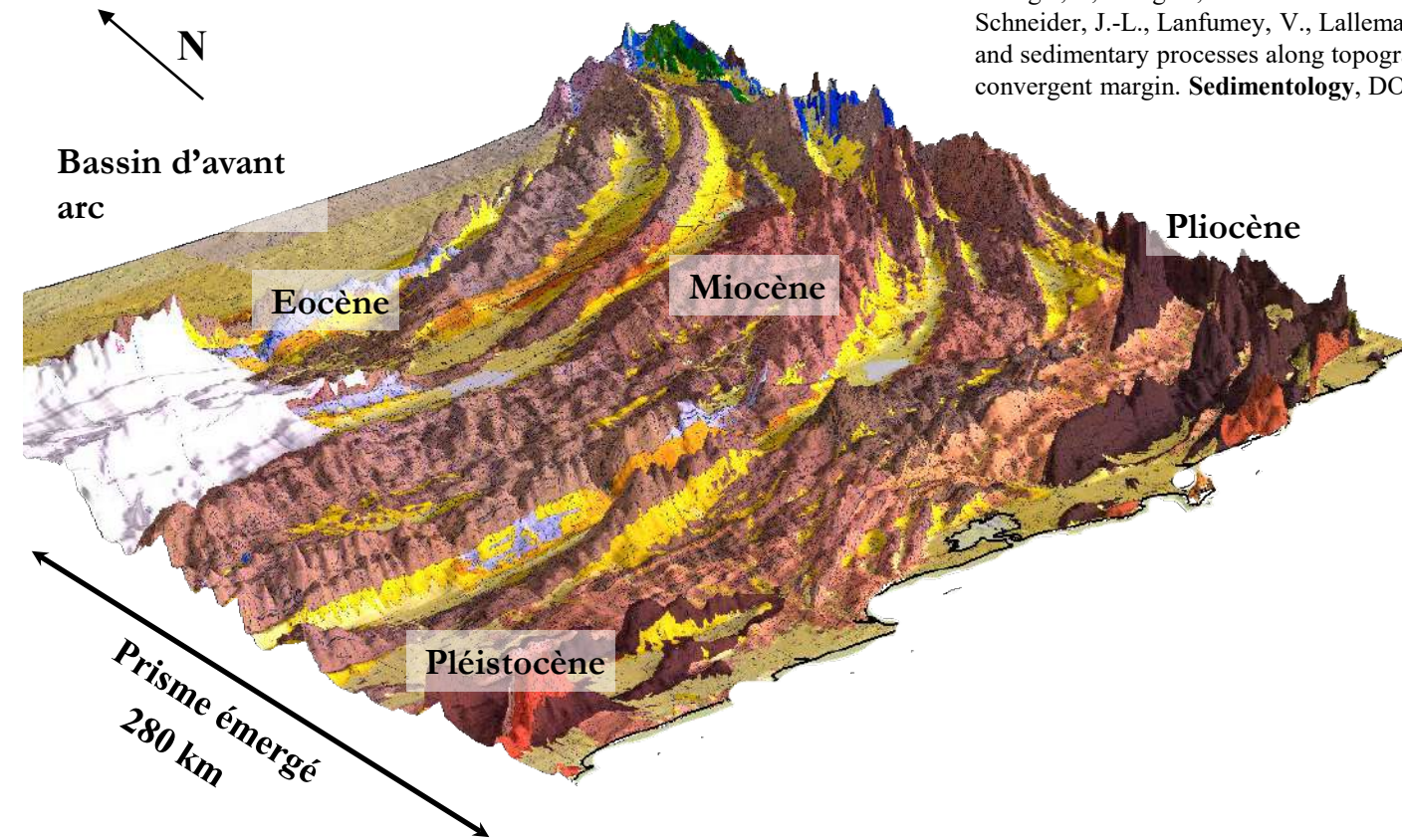
Océan Indien







Bourget, J., Zaragosi, S., Ellouz-Zimmermann, N., Mouchot, N., Garlan, T., Schneider, J.-L., Lanfumey, V., Lallemand, S. (2011) Turbidite system architecture and sedimentary processes along topographically complex slopes: the Makran convergent margin. *Sedimentology*, DOI 10.1111/j.1365-3091.2010.01168.x

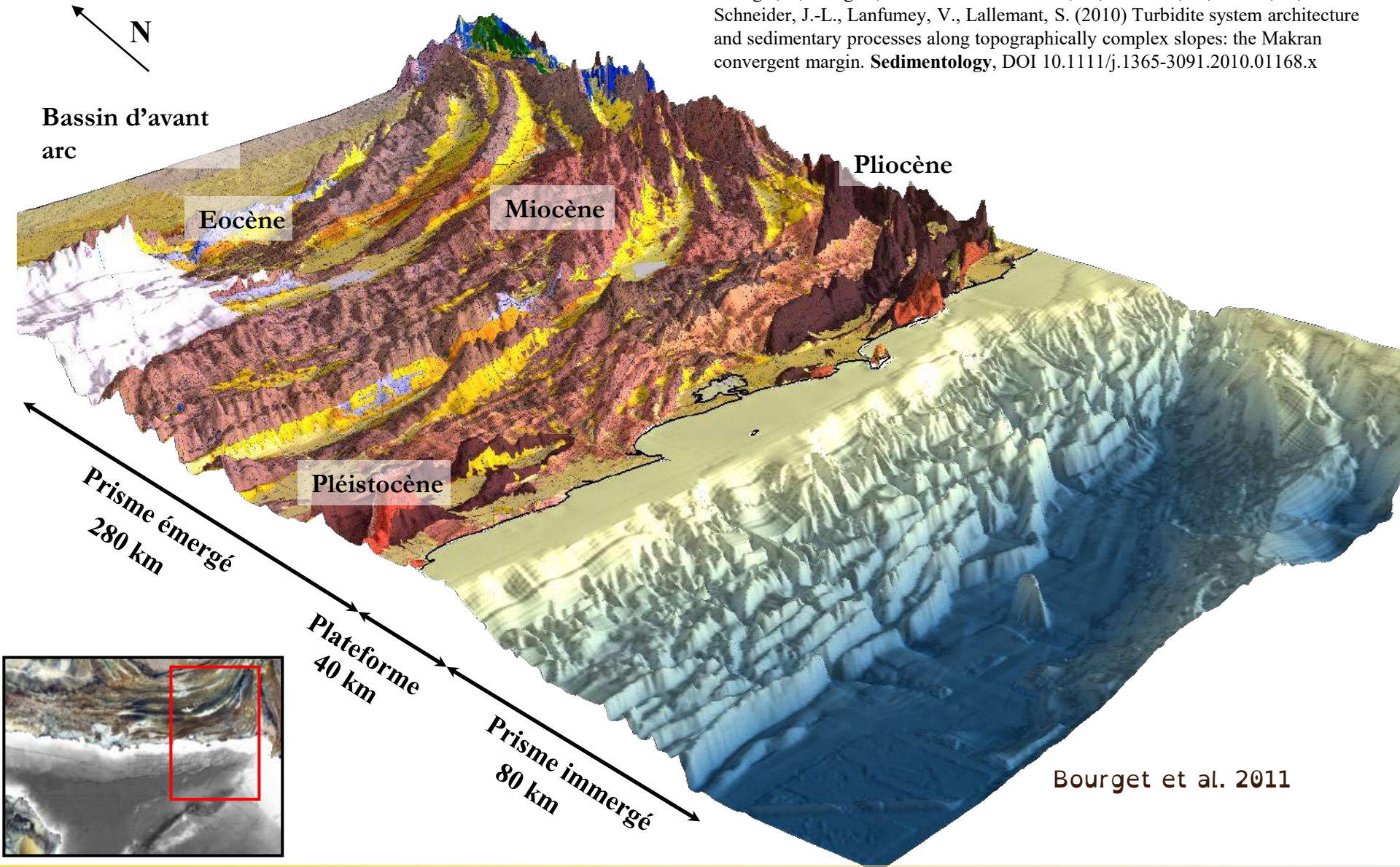


Bourget et al. 2011

**Prisme d'accrétion : domaine continental**



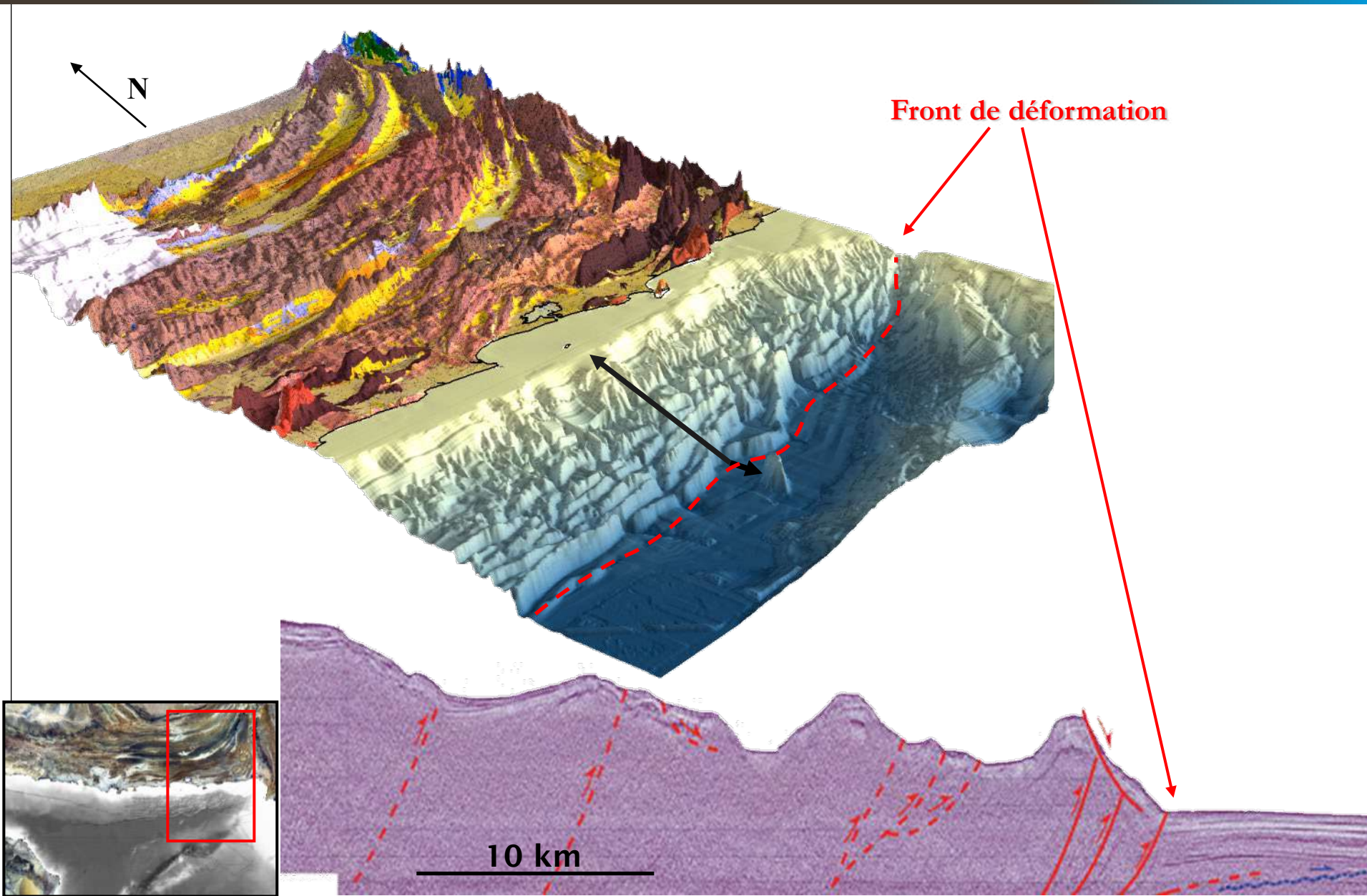
Bourget, J., Zaragosi, S. Ellouz-Zimmermann, N., Mouchot, N., Garlan, T., Schneider, J.-L., Lanfumey, V., Lallemand, S. (2010) Turbidite system architecture and sedimentary processes along topographically complex slopes: the Makran convergent margin. *Sedimentology*, DOI 10.1111/j.1365-3091.2010.01168.x



Bourget et al. 2011

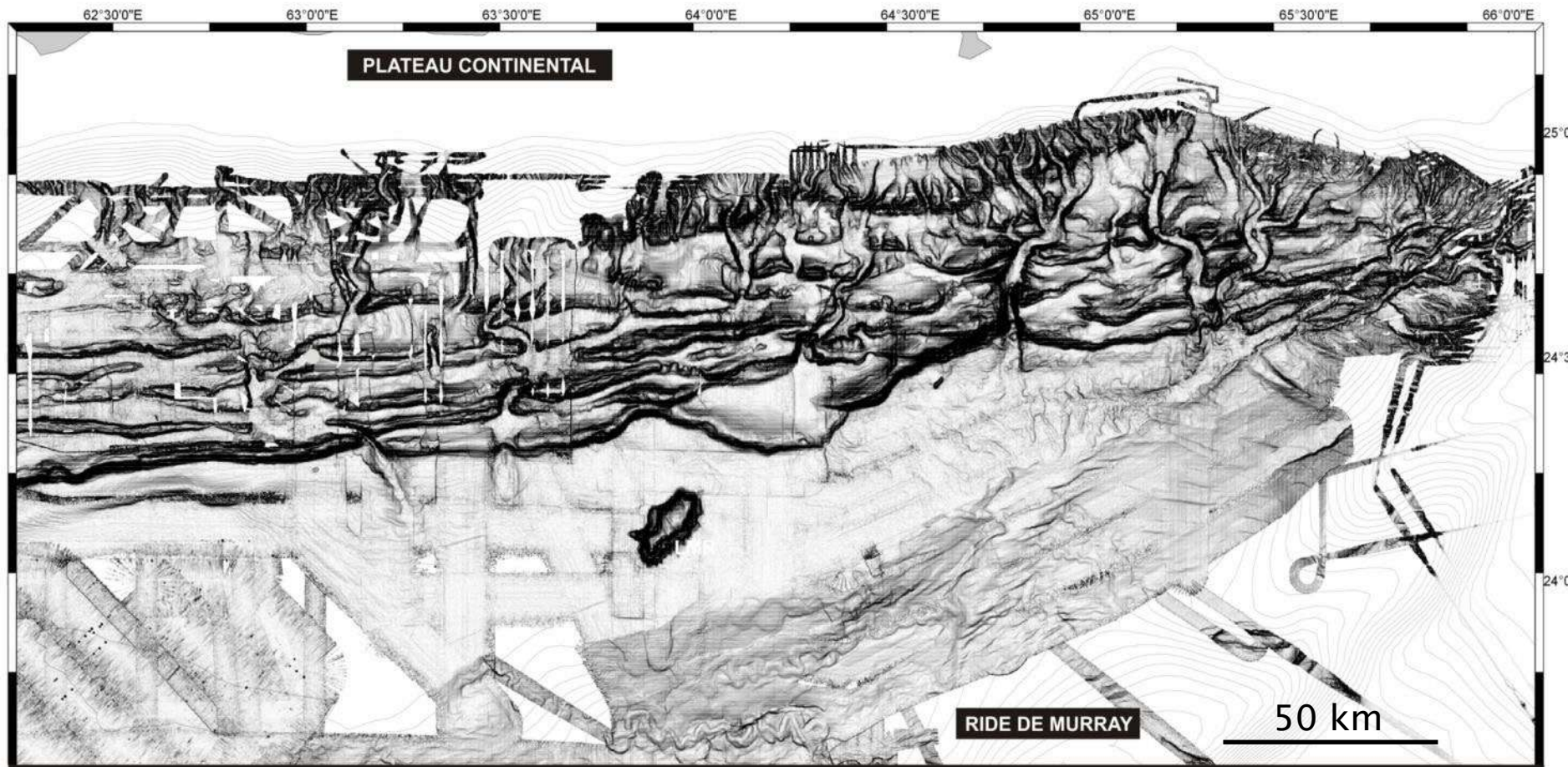
Prisme d'accrétion : domaine continental / sous-marin





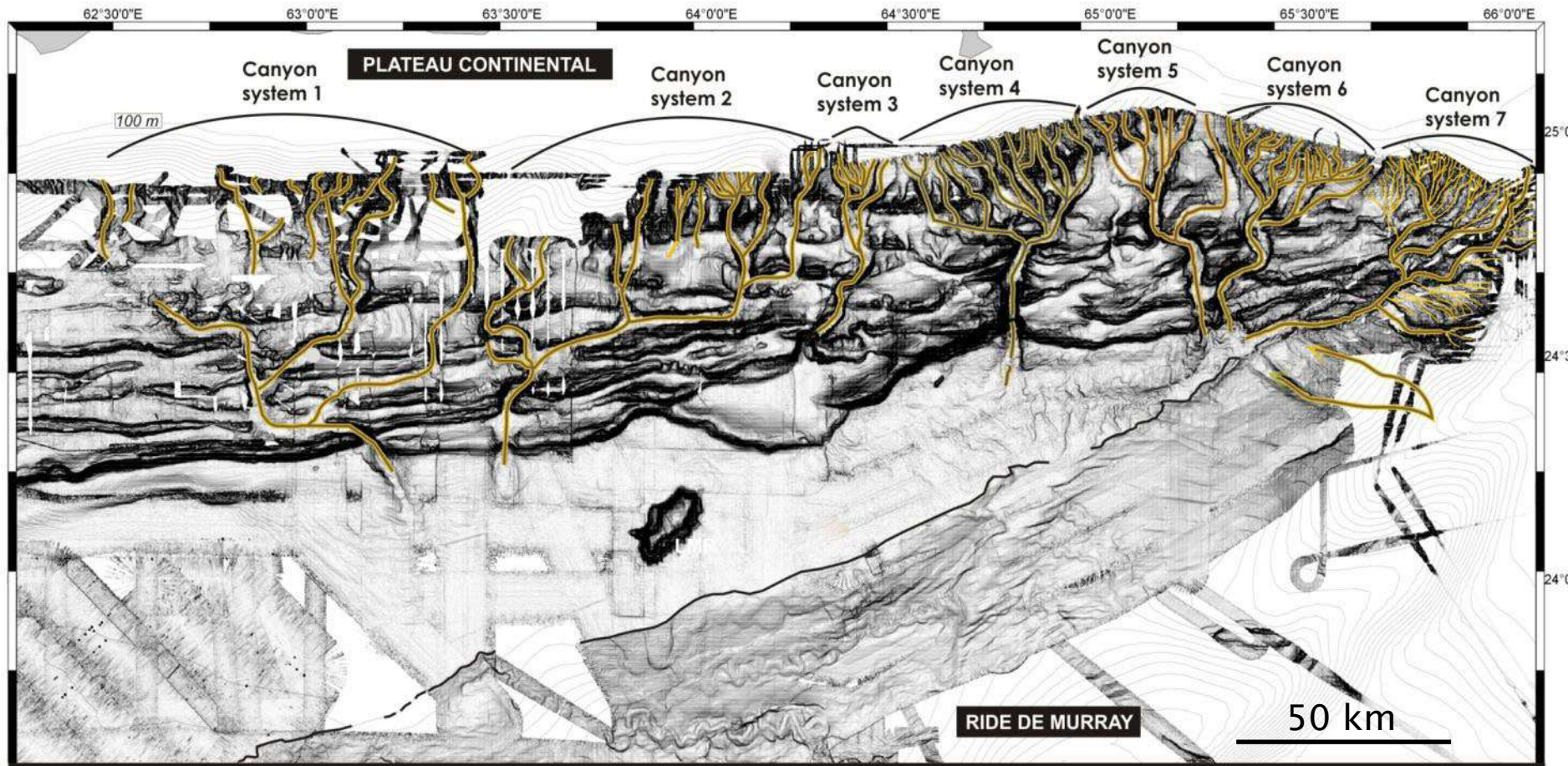
Rides d'accrétion – bassins intrapentes (piggy-back)





Bourget et al. 2011

carte des pentes

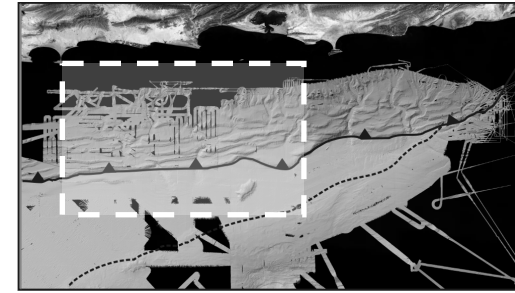
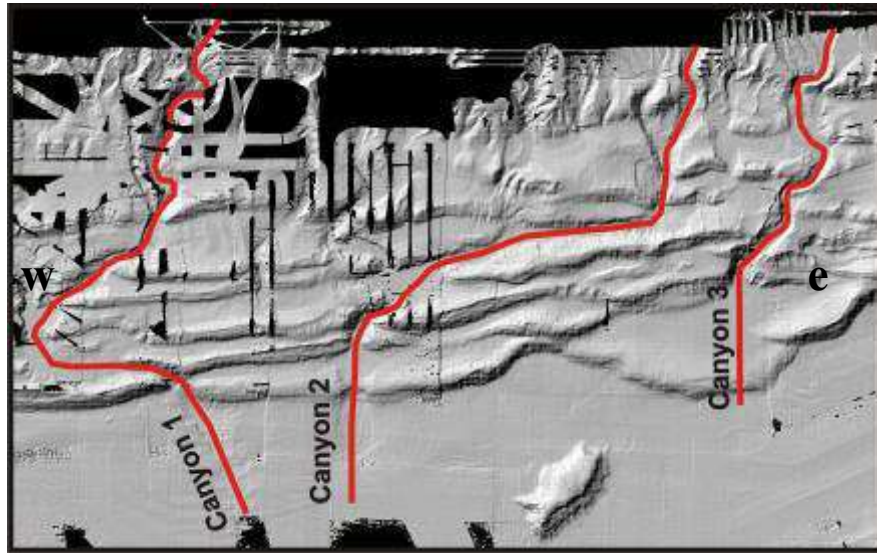


Bourget et al. 2011

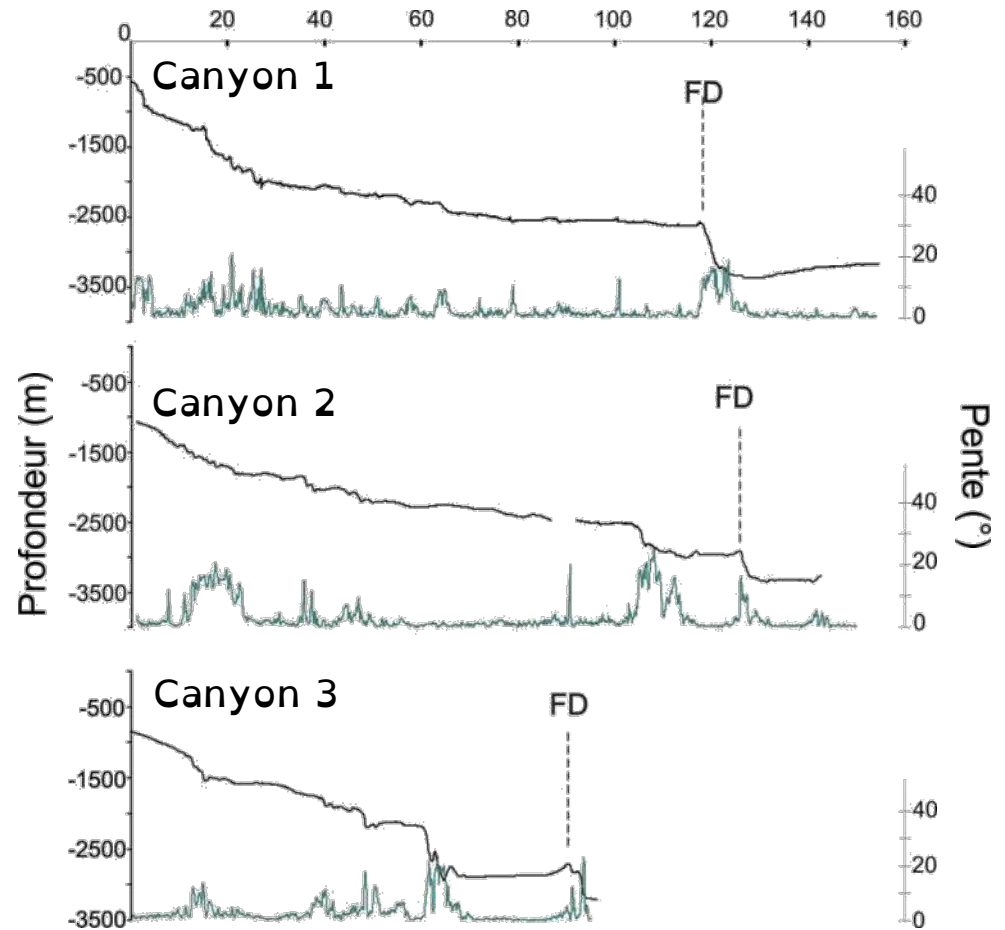
carte des pentes



# MAKRAN OCCIDENTAL

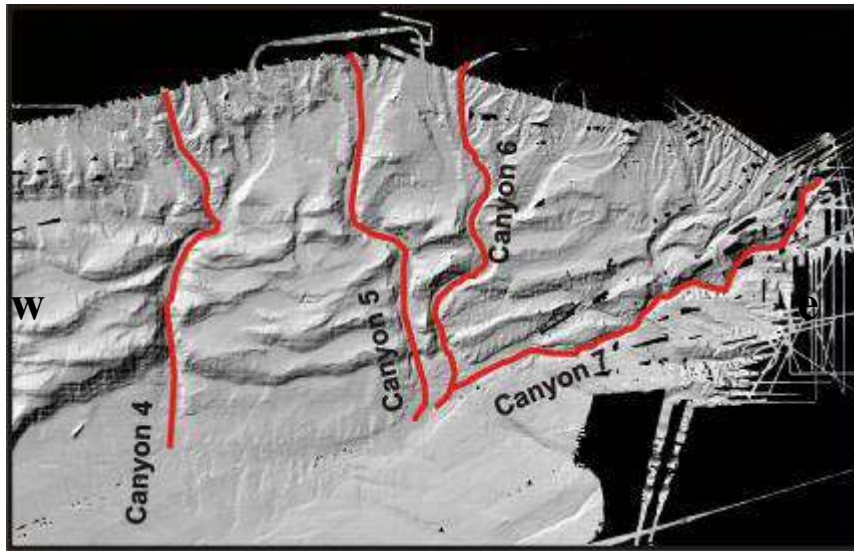


FD: front de déformation



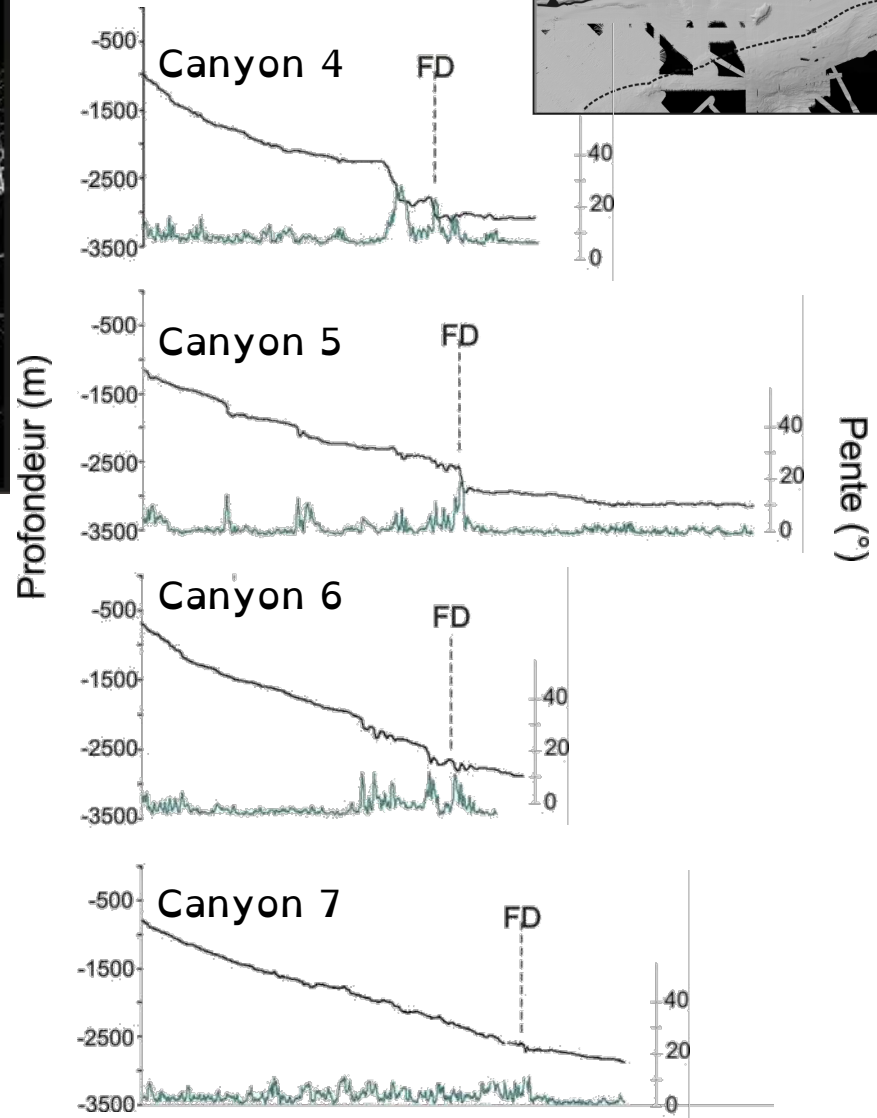
Bourget et al. 2011

# MAKRAN ORIENTAL

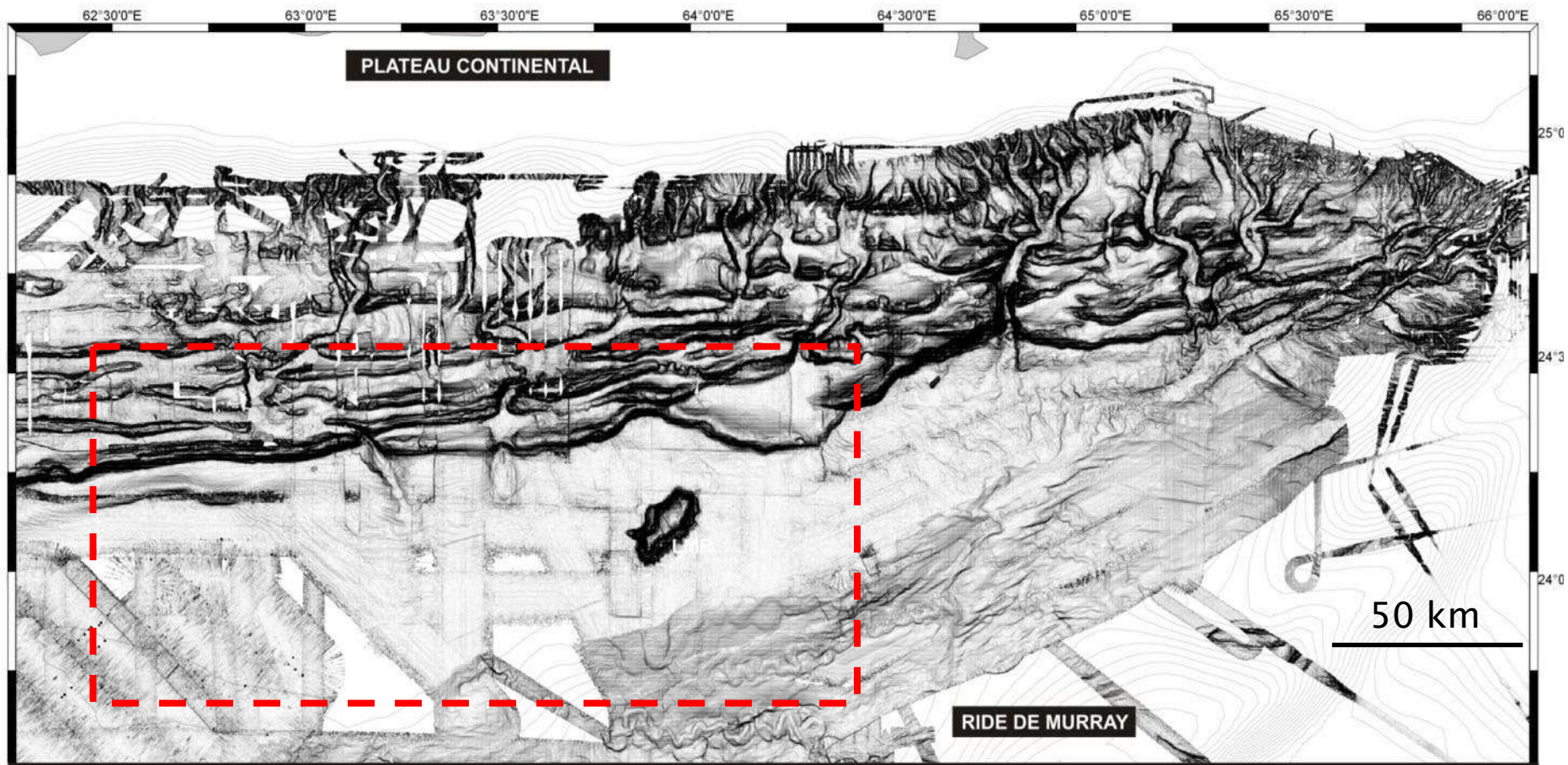


Bourget et al. 2011

FD: front de déformation

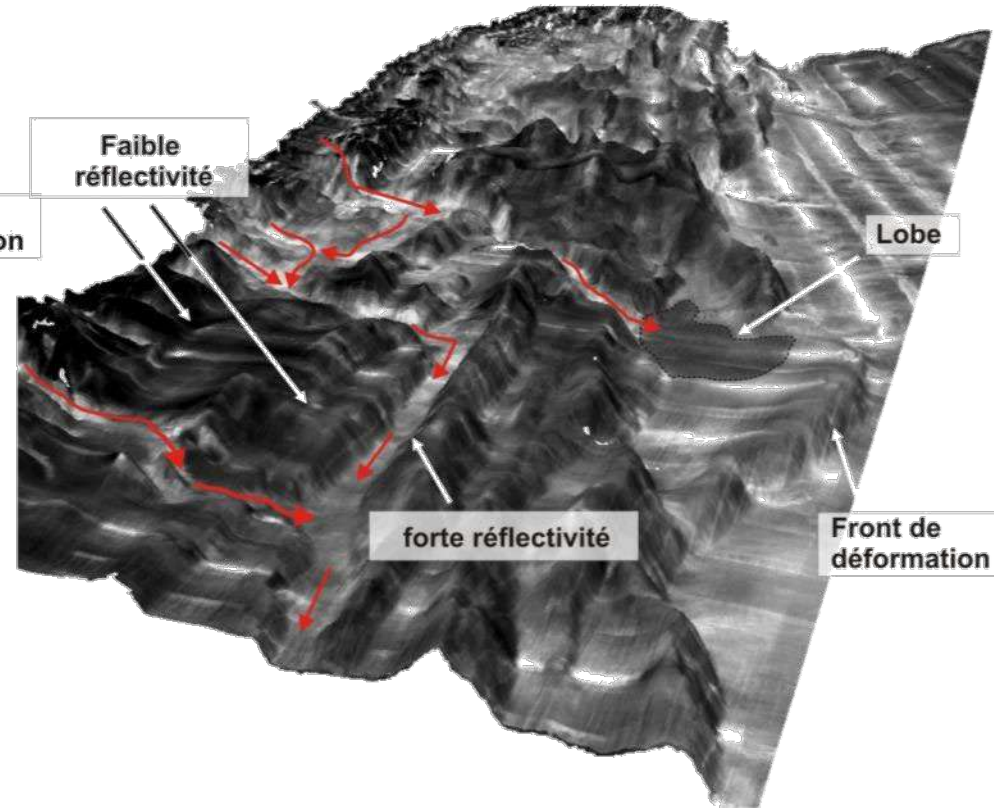
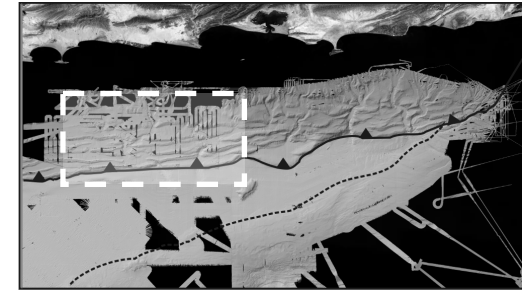
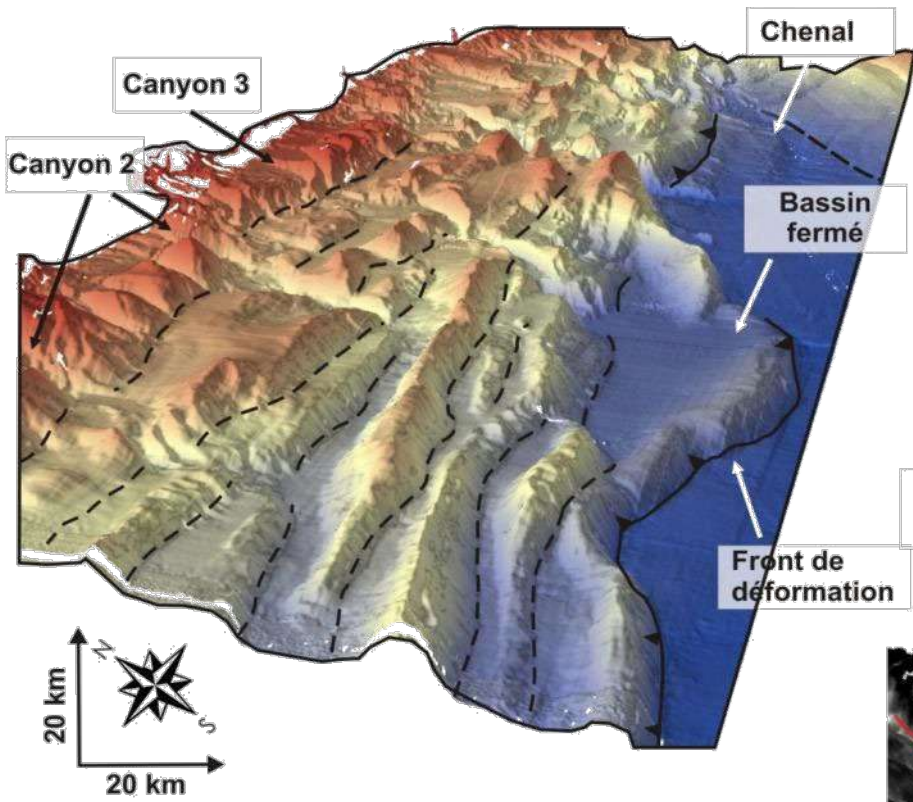






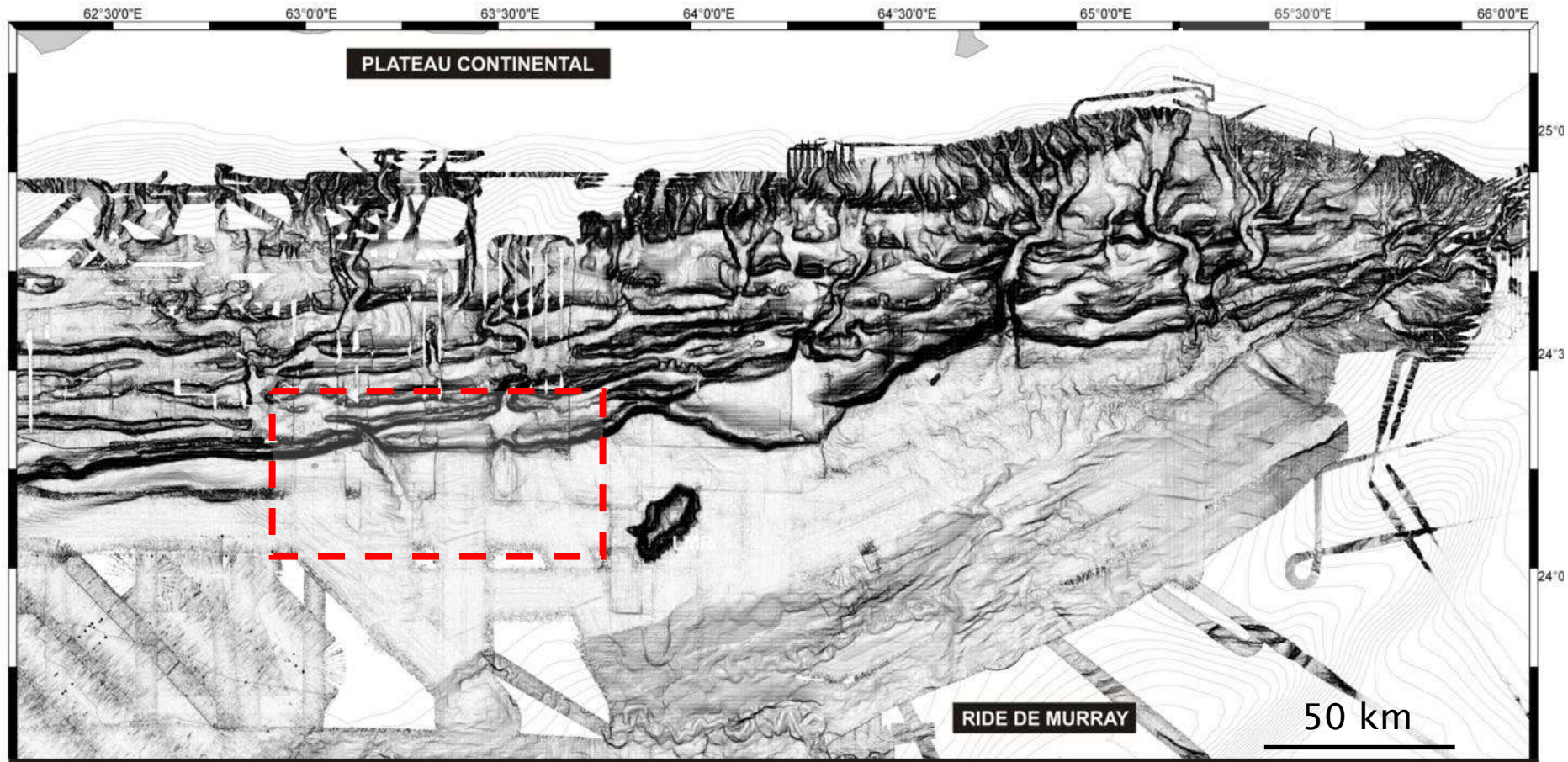
← Variabilité ouest / est →

Bourget et al. 2011



Bourget et al. 2011

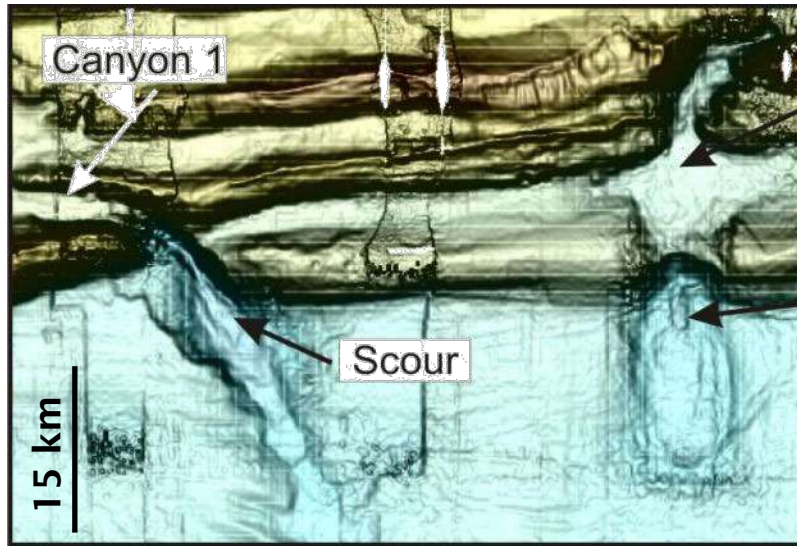




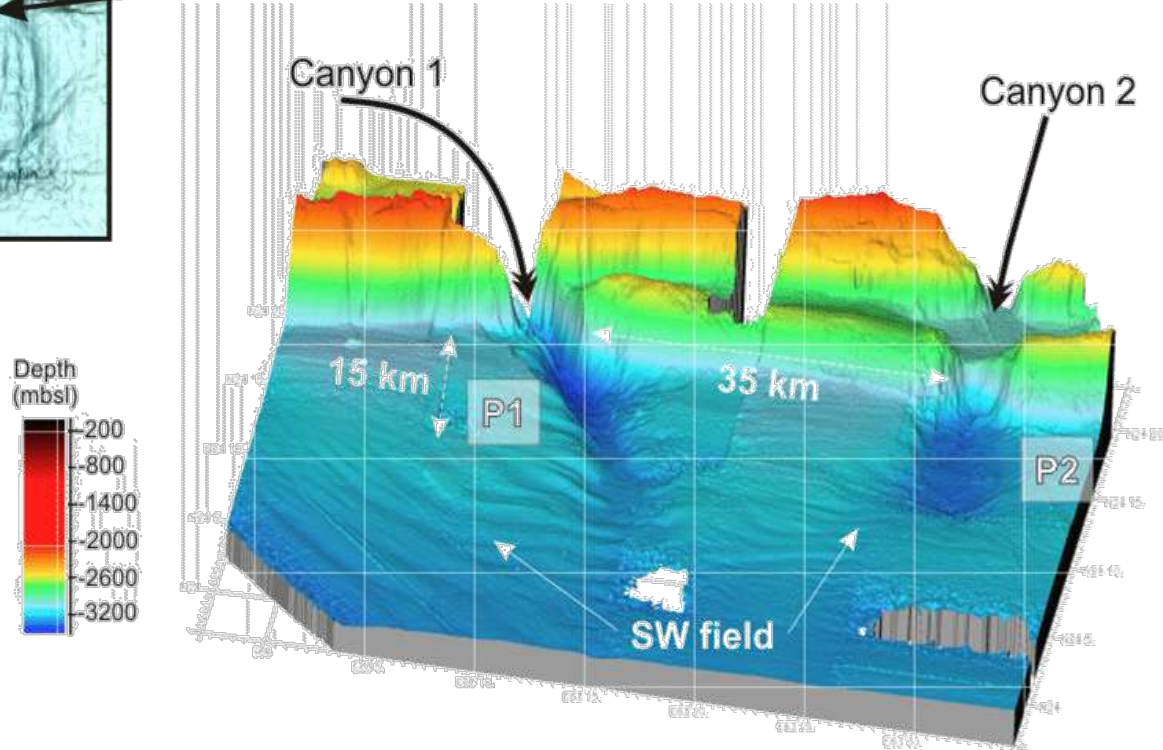
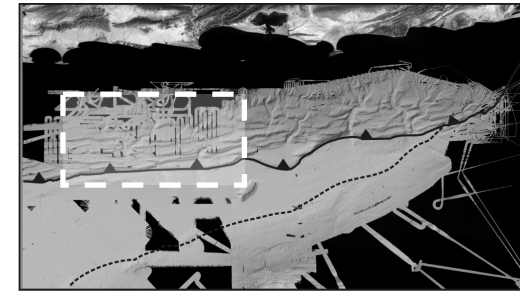
← Variabilité ouest / est →

Bourget et al. 2011

# MAKRAN OCCIDENTAL



Bourget et al. 2011

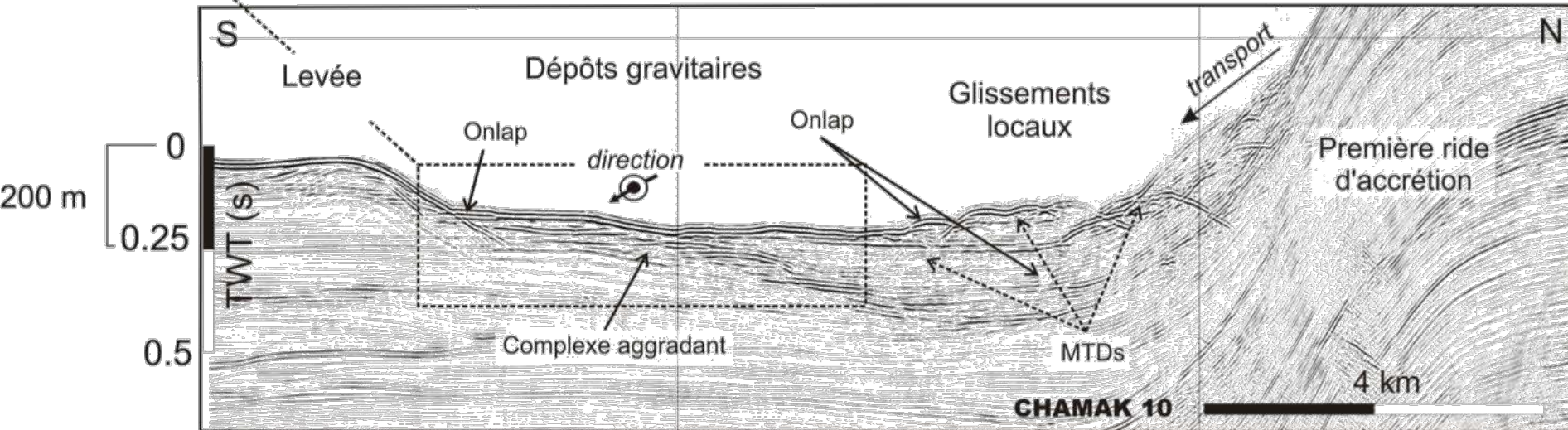
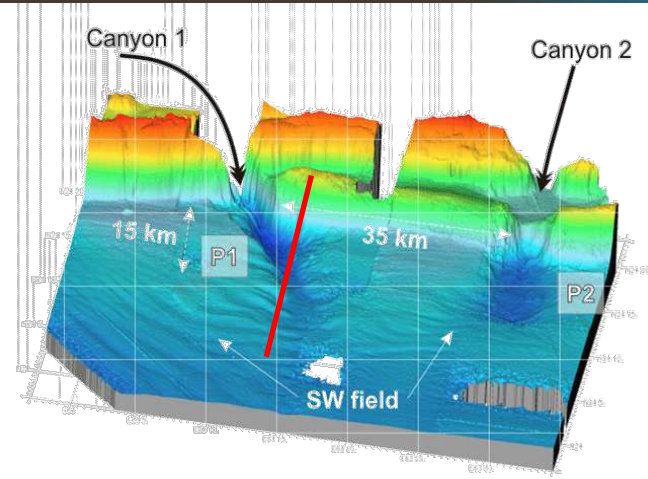
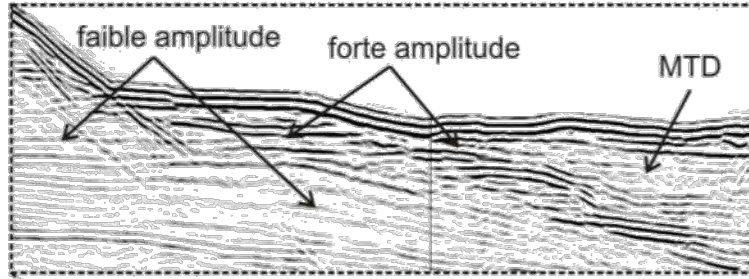


Débouché des canyons occidentaux : piscines d'érosion pluri-kilométriques





# MAKRAN OCCIDENTAL

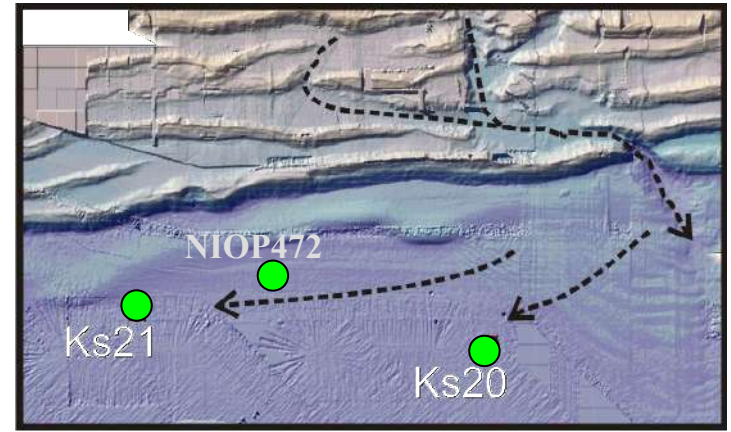
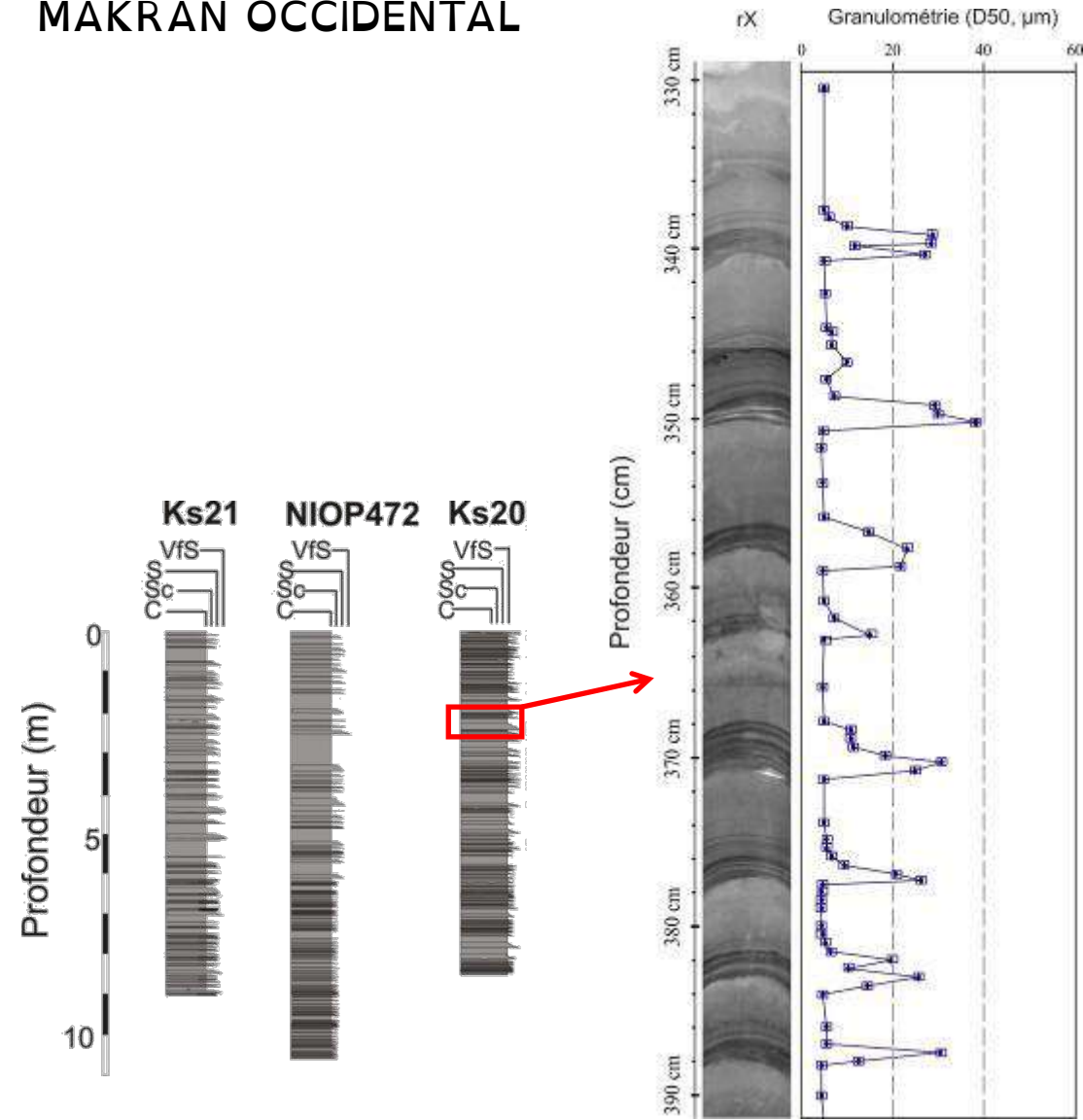


Bourget et al. 2011

Débouché des canyons occidentaux : piscines d'érosion pluri-kilométriques



# MAKRAN OCCIDENTAL



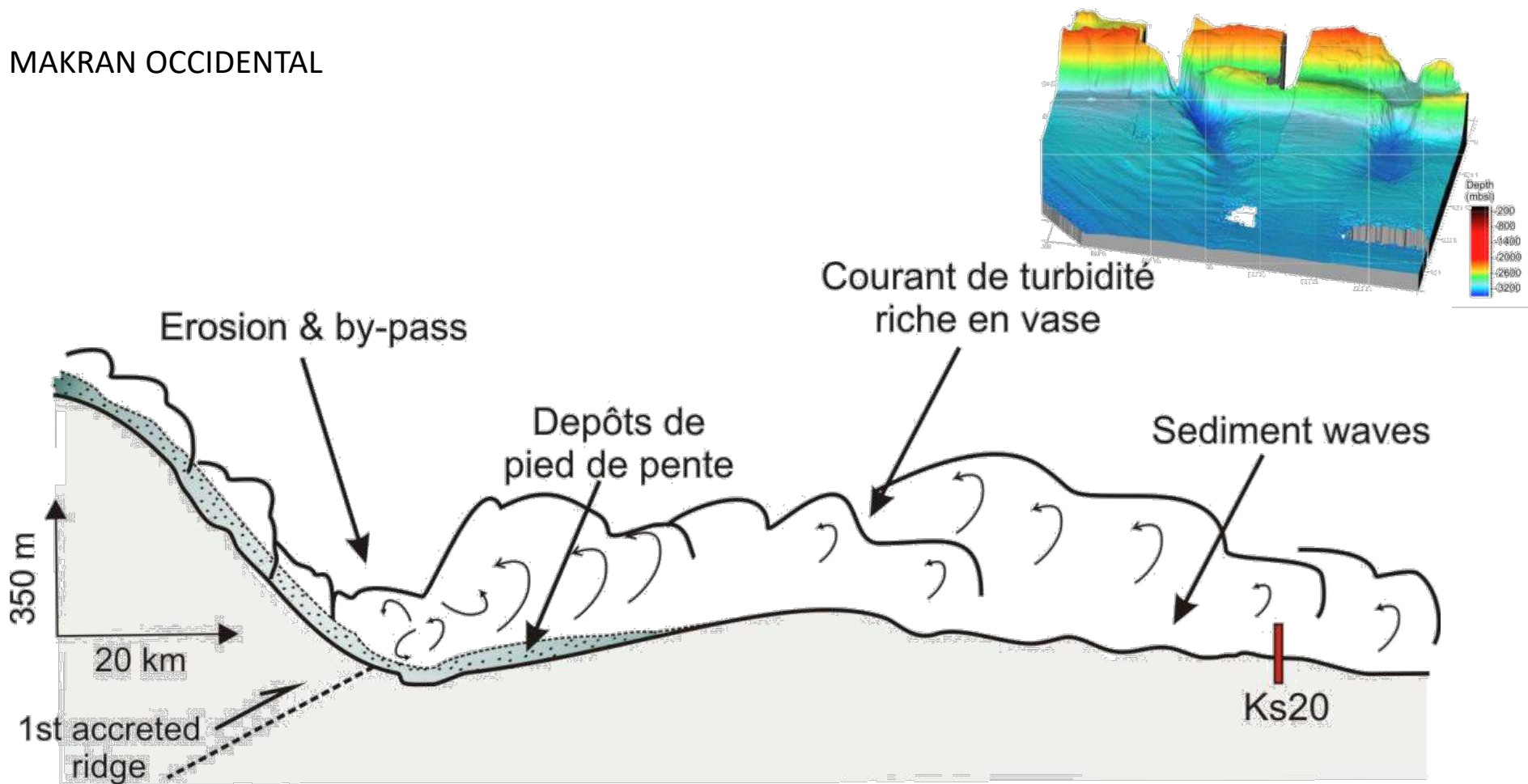
Bourget et al. 2011

Plaine abyssale : turbidites argilo-silteuses / écoulements non chenalisés





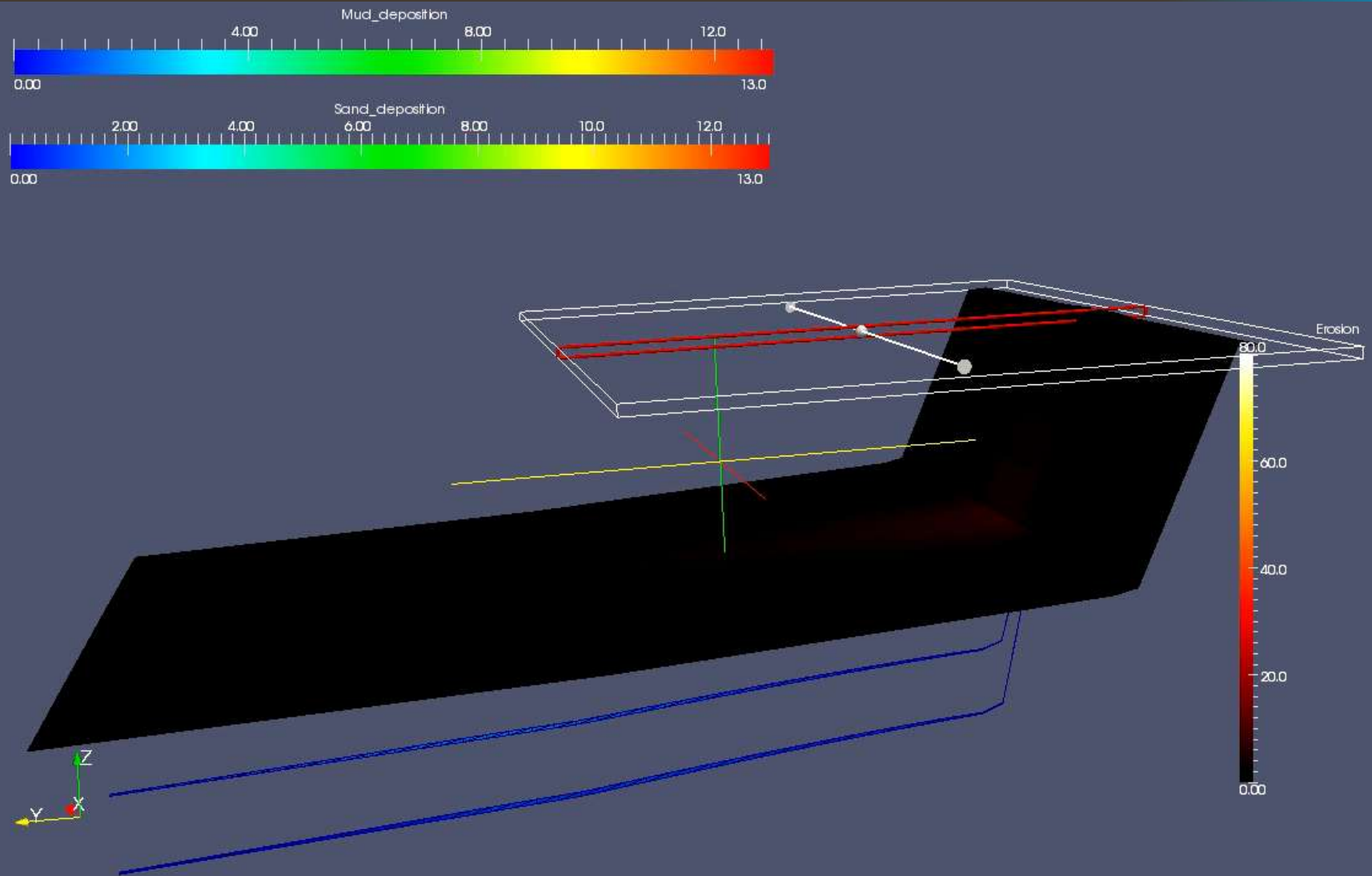
## MAKRAN OCCIDENTAL



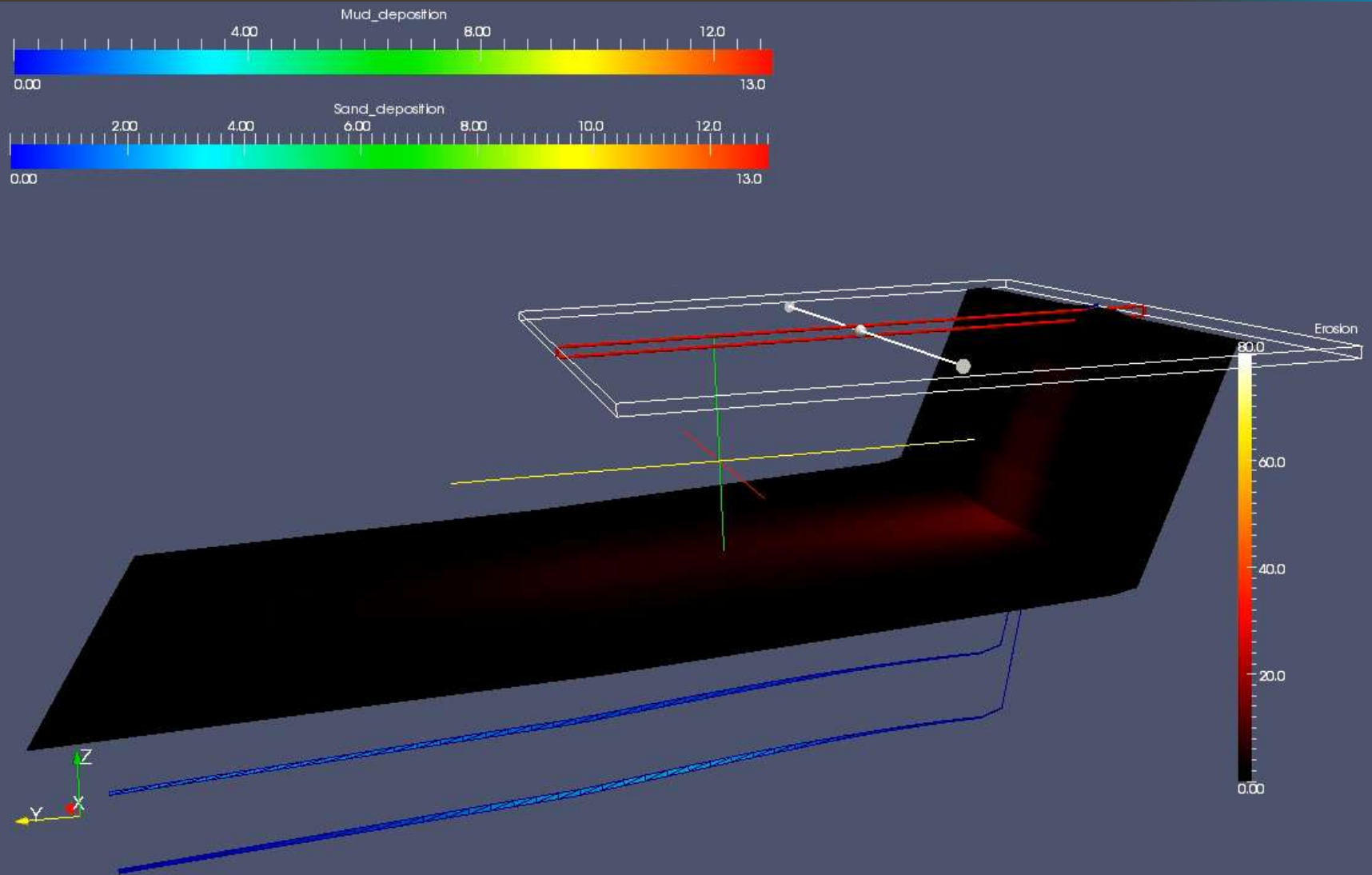
Bourget et al. 2011

**Piscines d'érosion : impact de la topographie sur la dynamique sédimentaire**

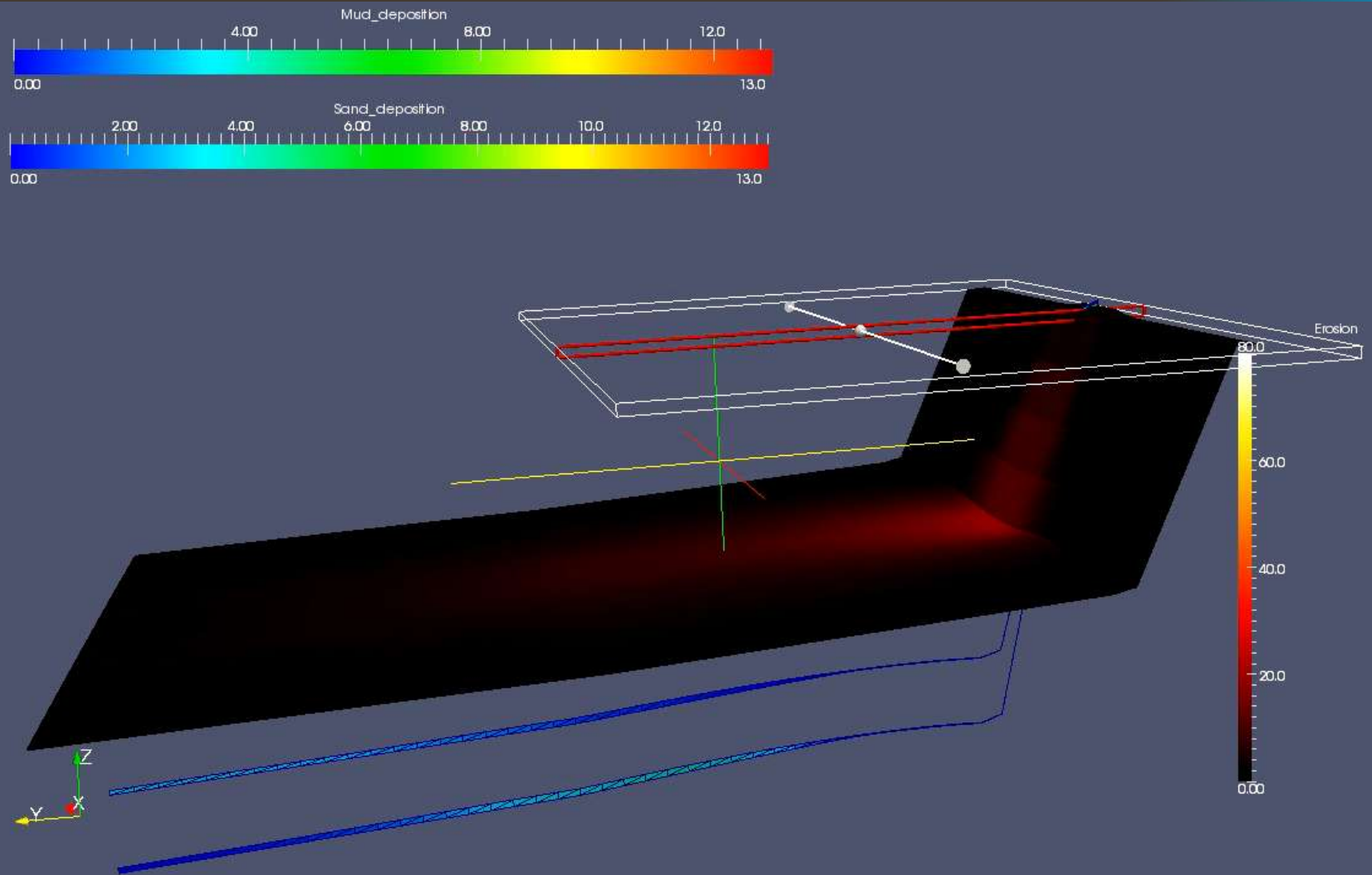
# La marge du Makran





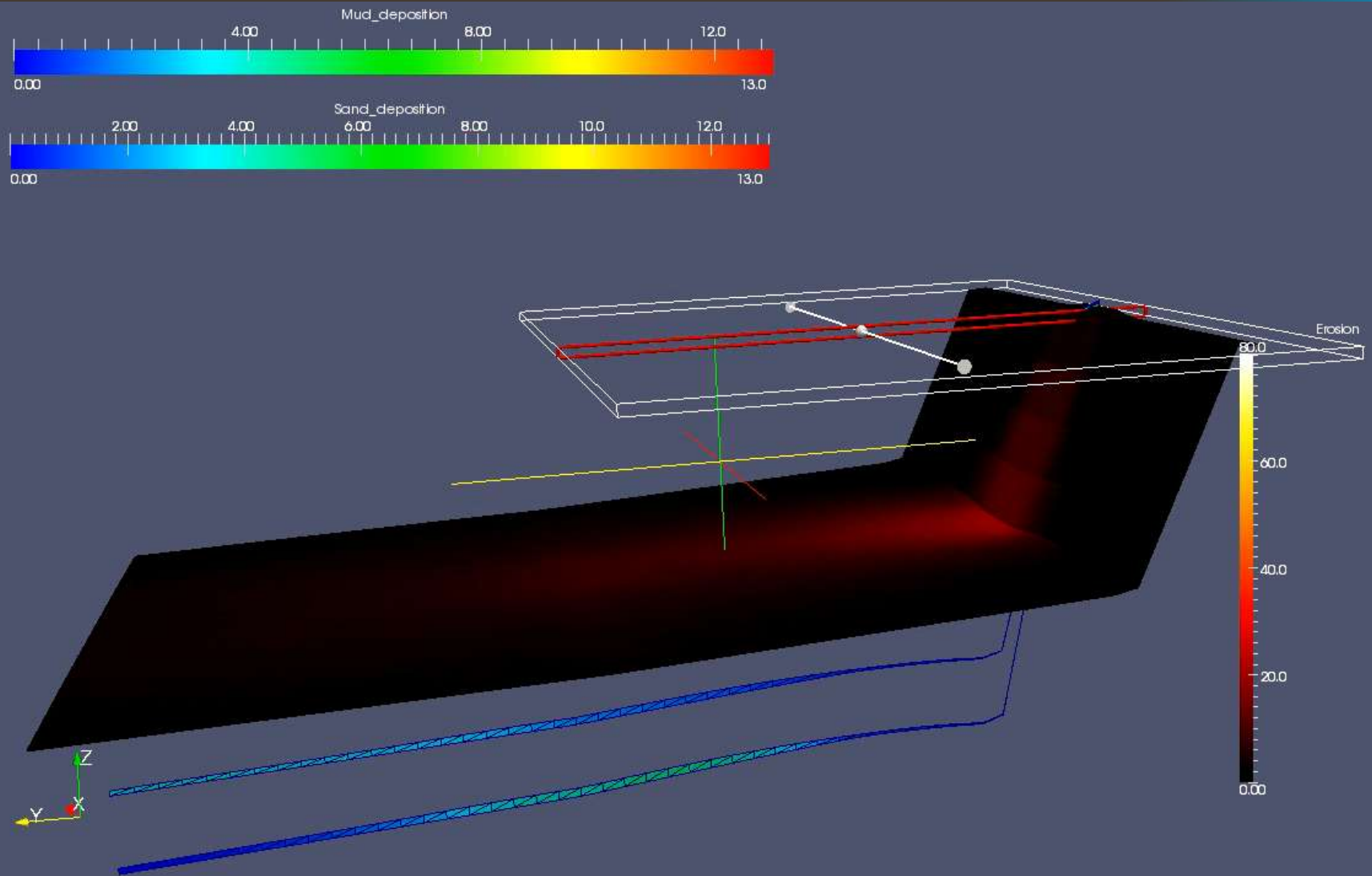


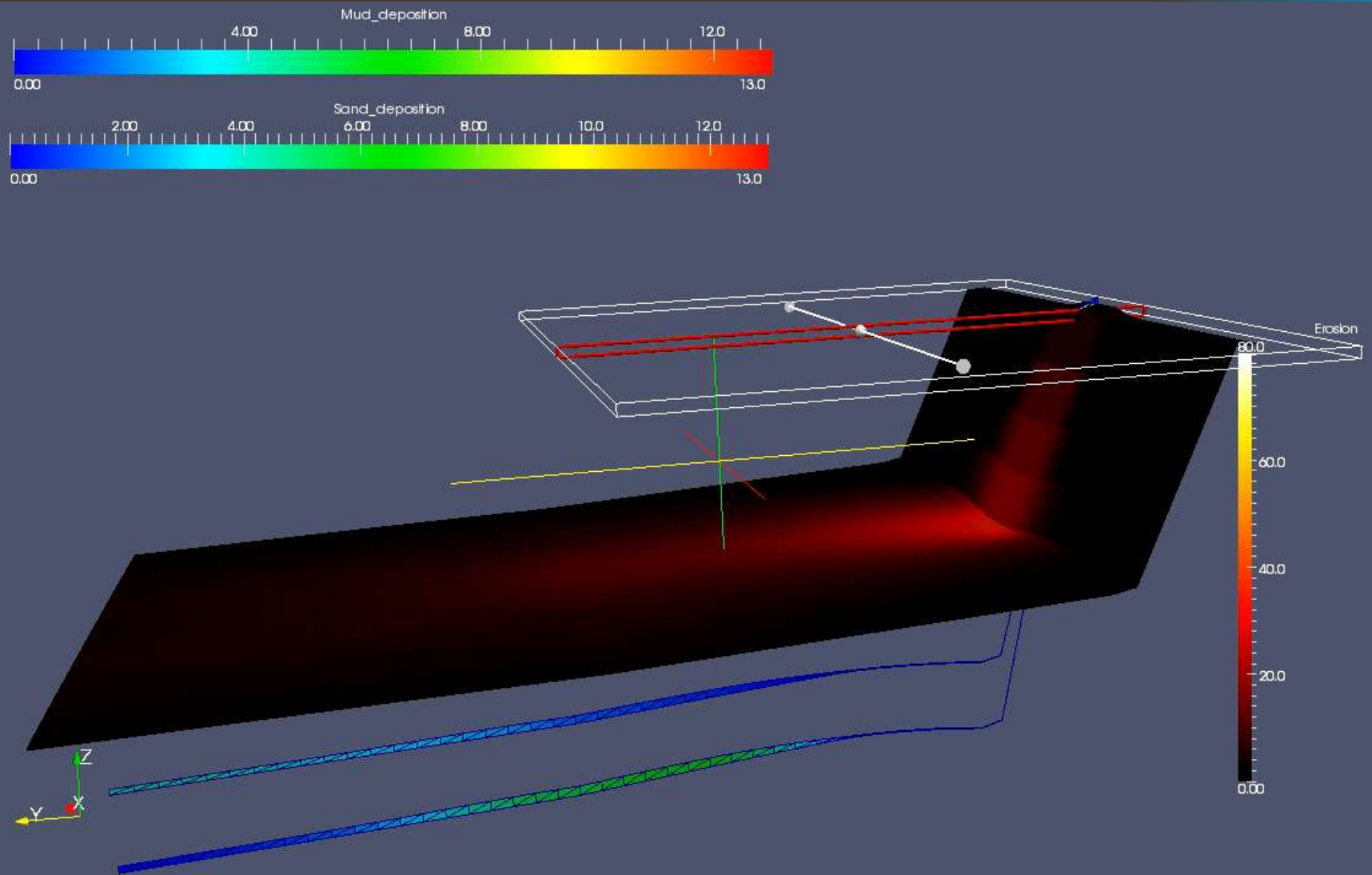
# La marge du Makran



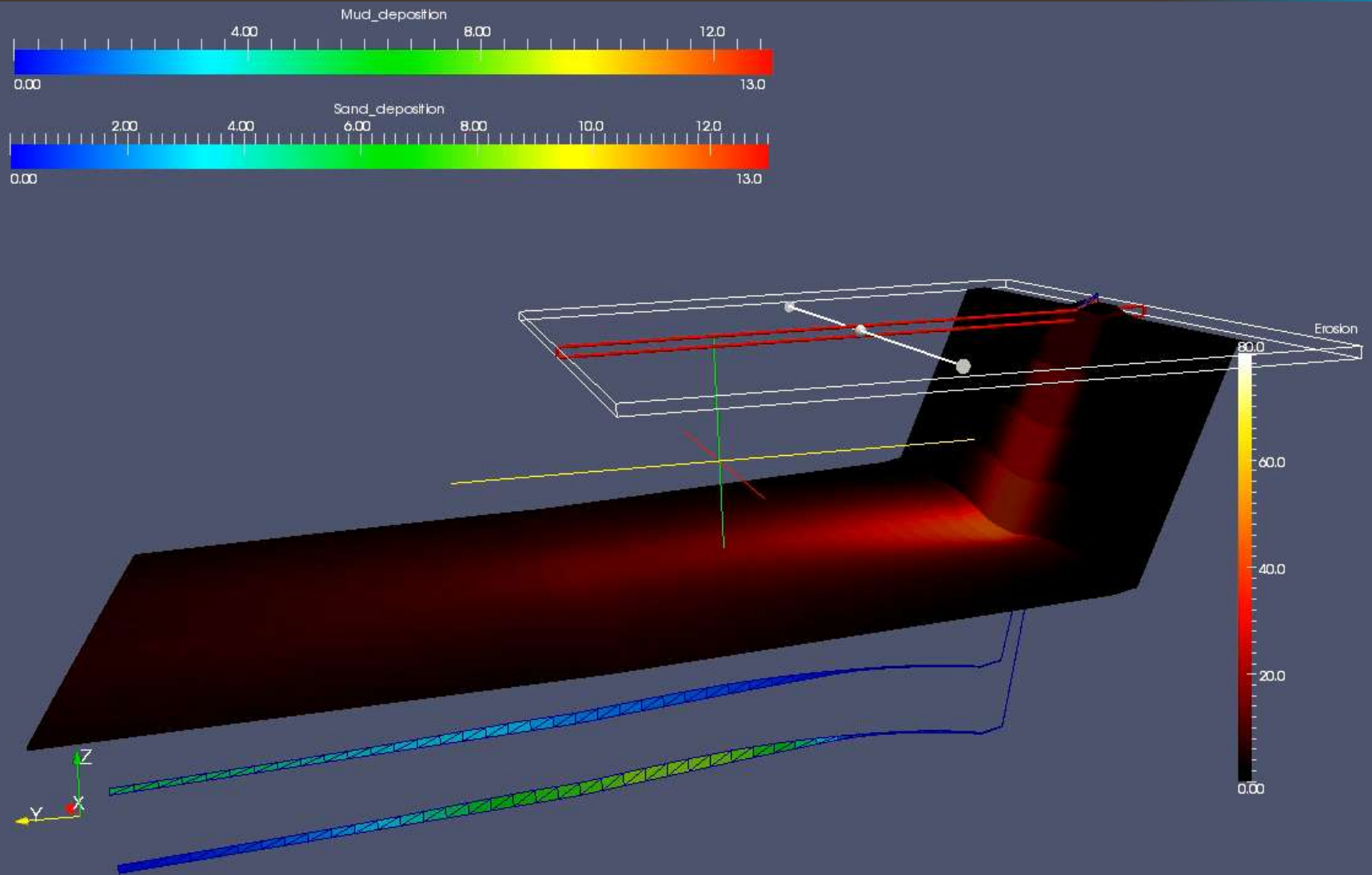


# La marge du Makran

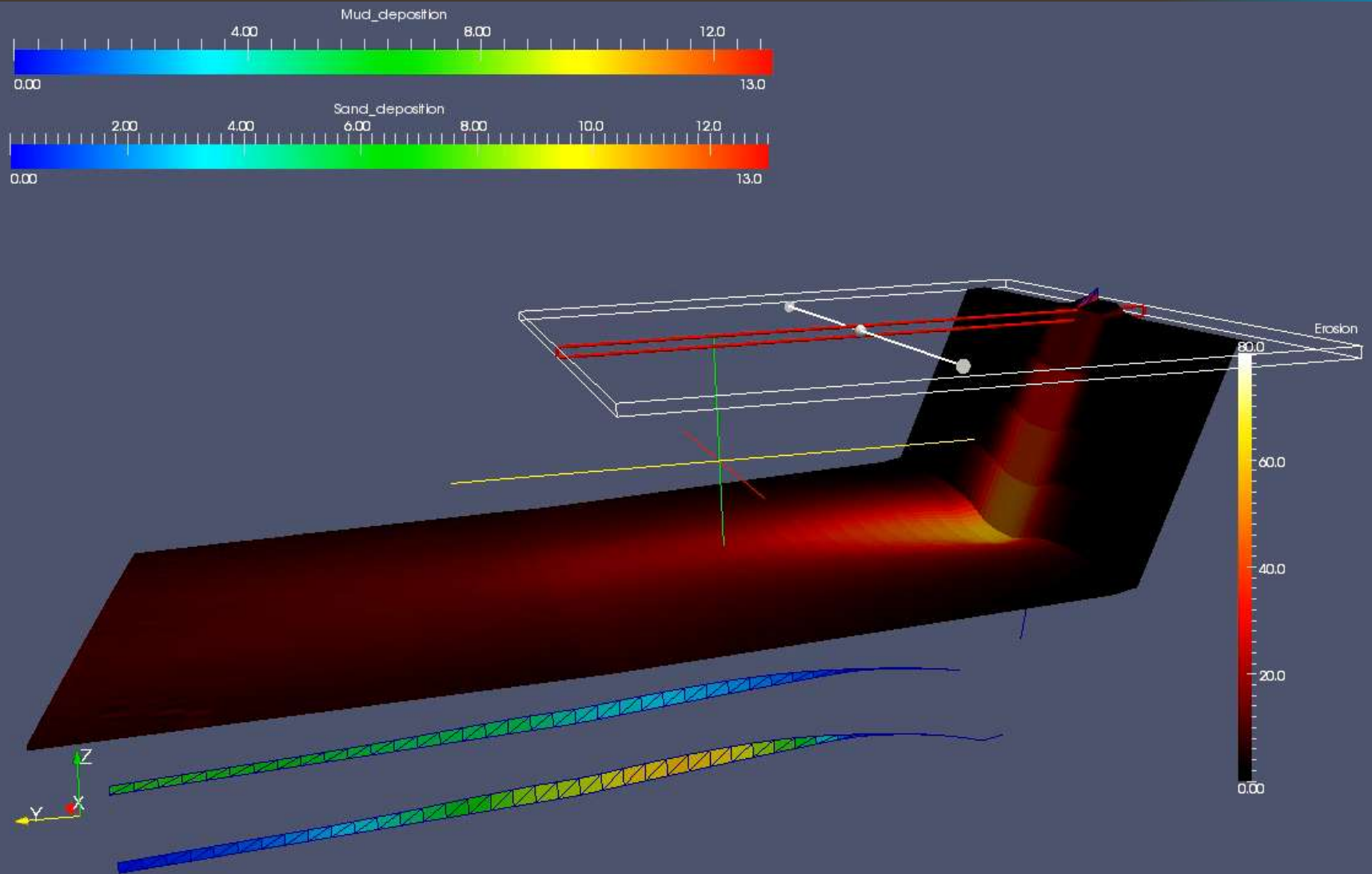






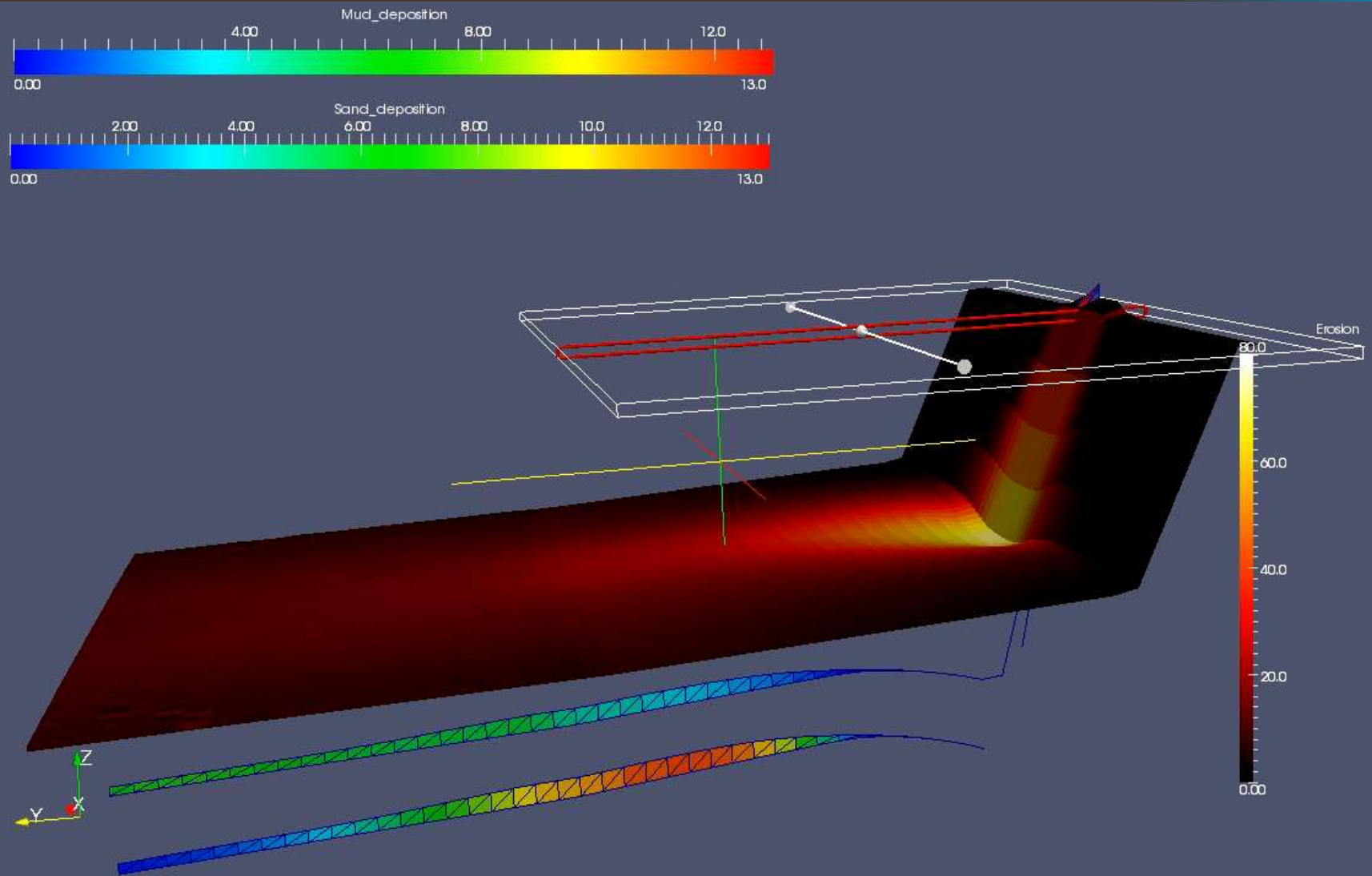


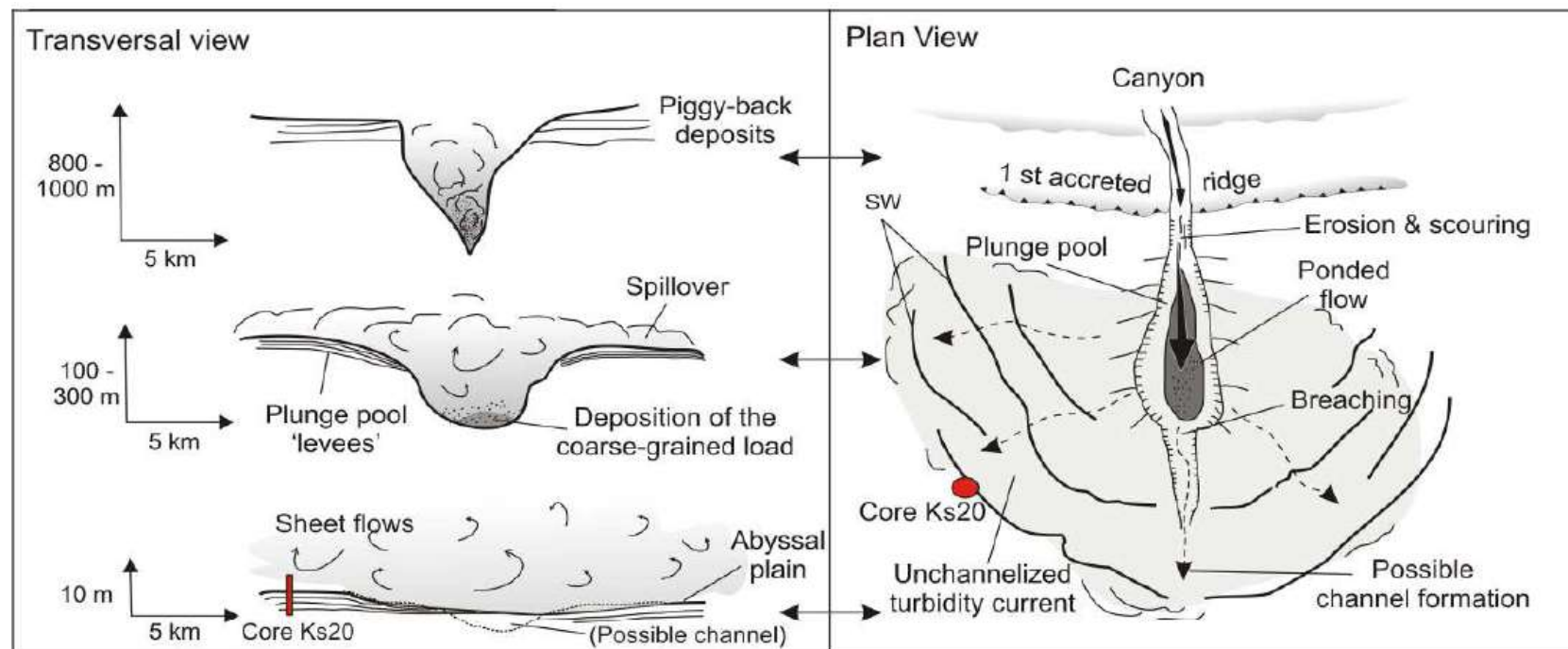
# La marge du Makran



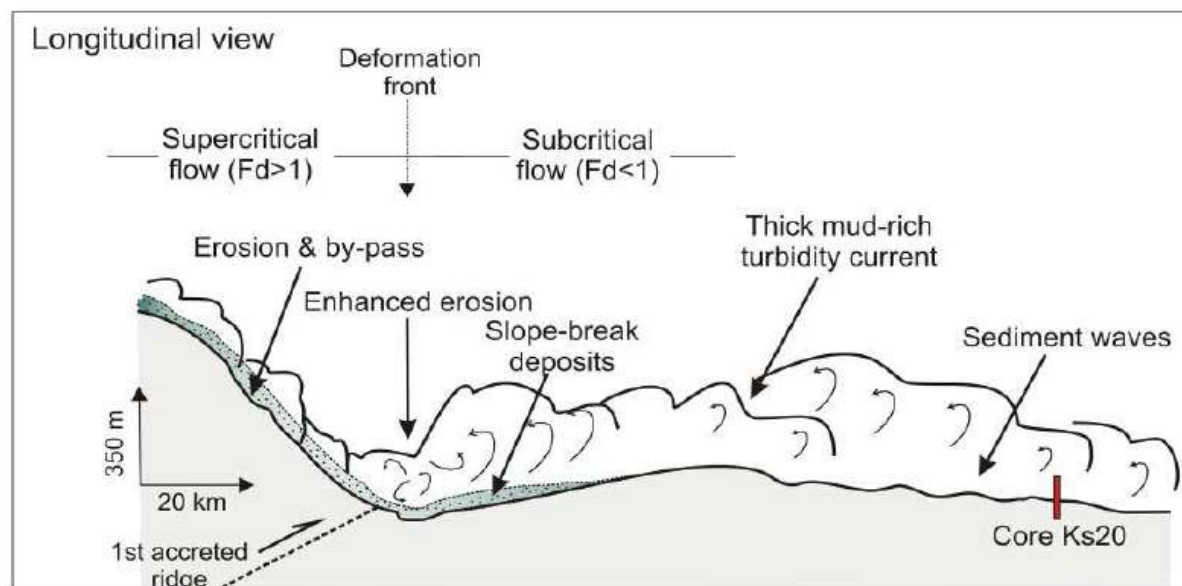


# La marge du Makran

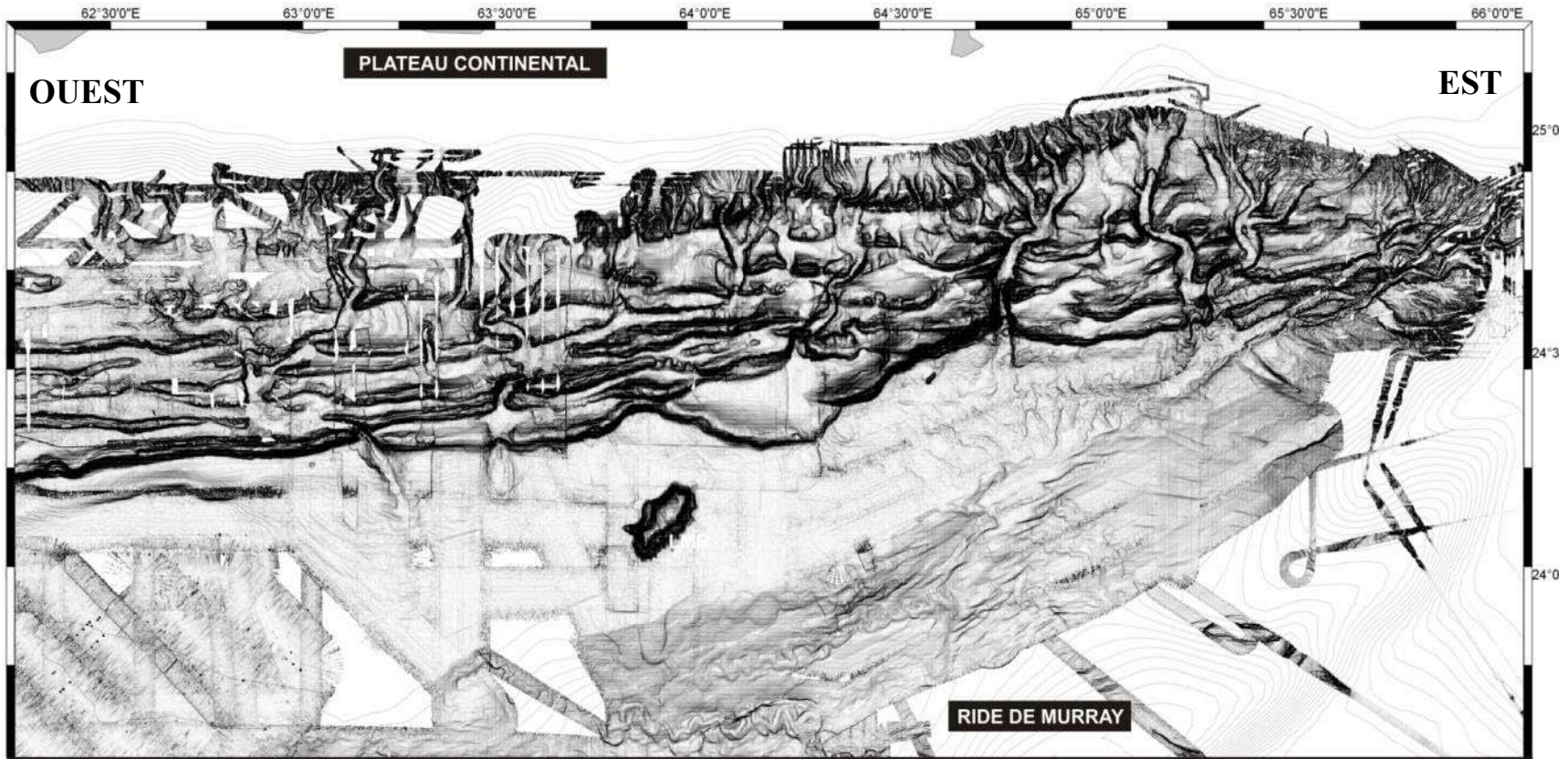




Bourget et al. 2011

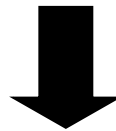






Variabilité EST-OUEST

Bourget et al. 2011



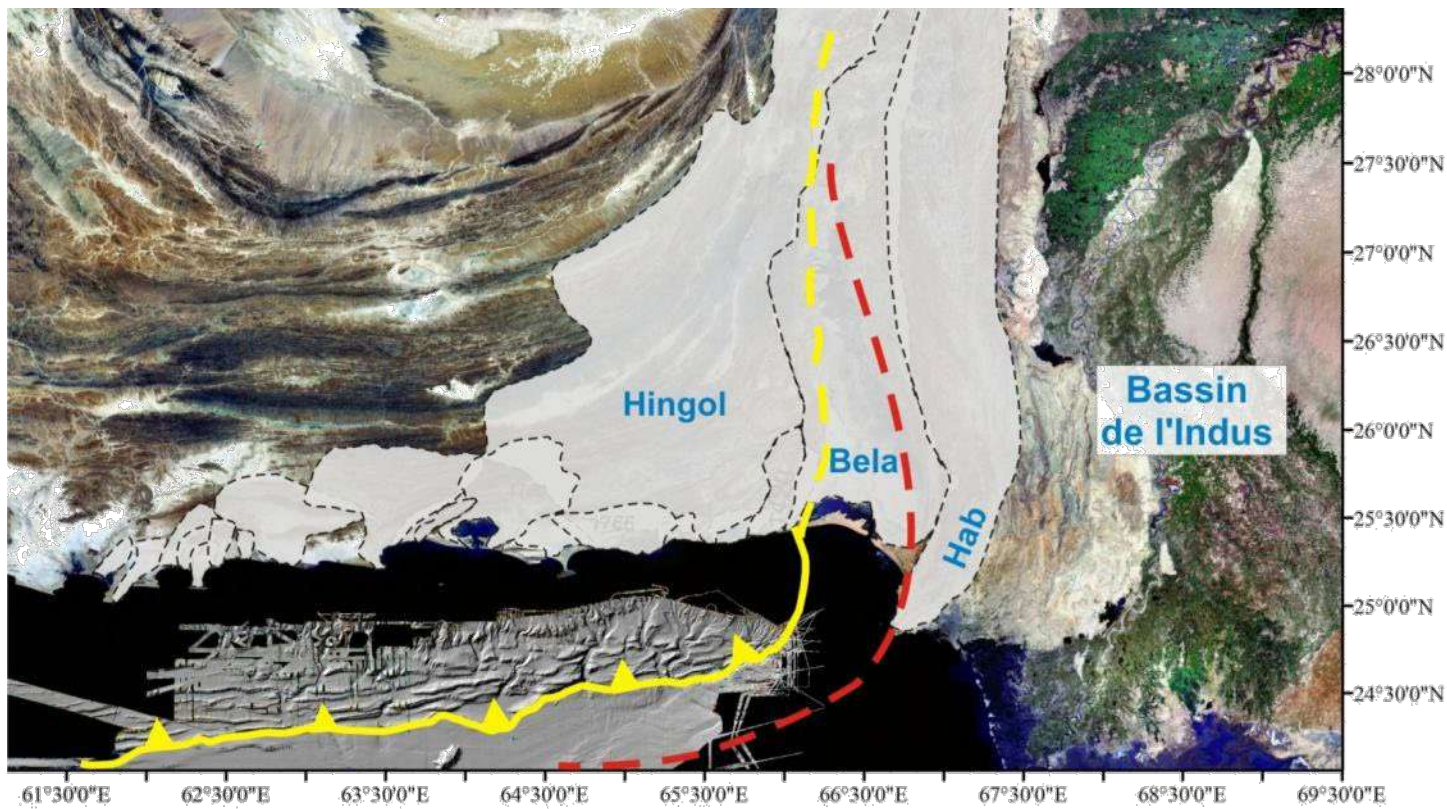
DEFORMATION

**VS**

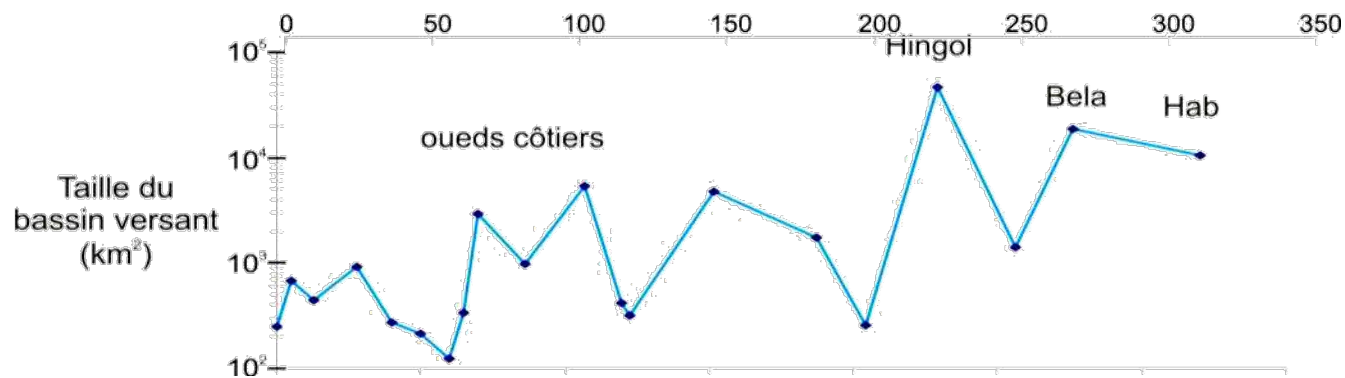
FLUX SEDIMENTAIRES

OUEST

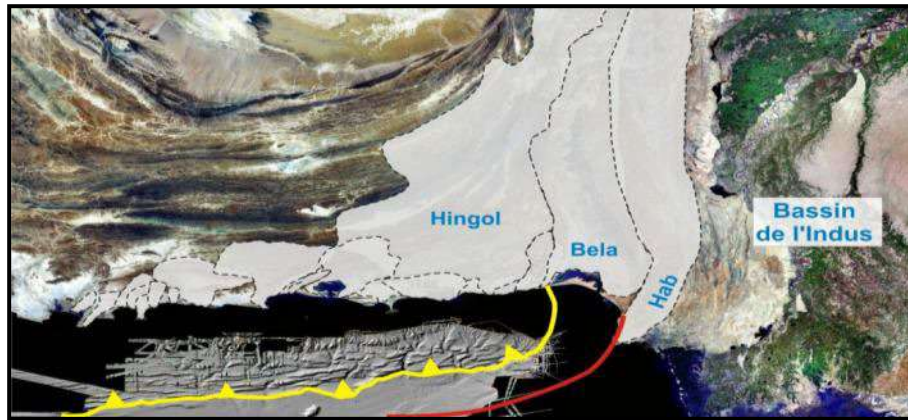
EST



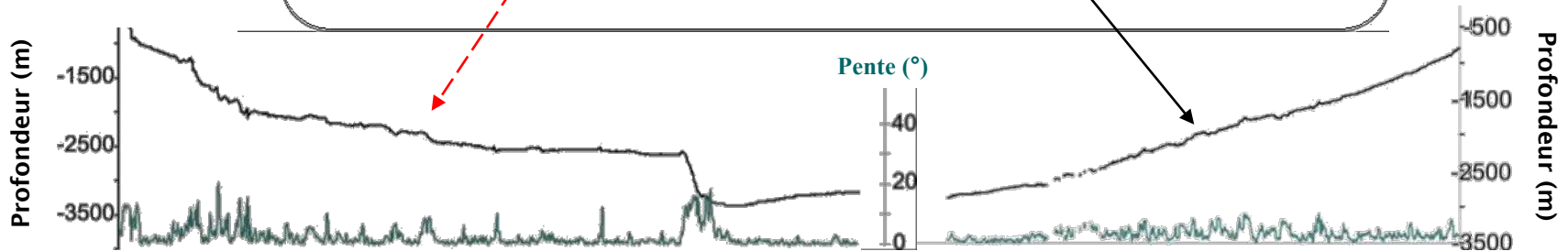
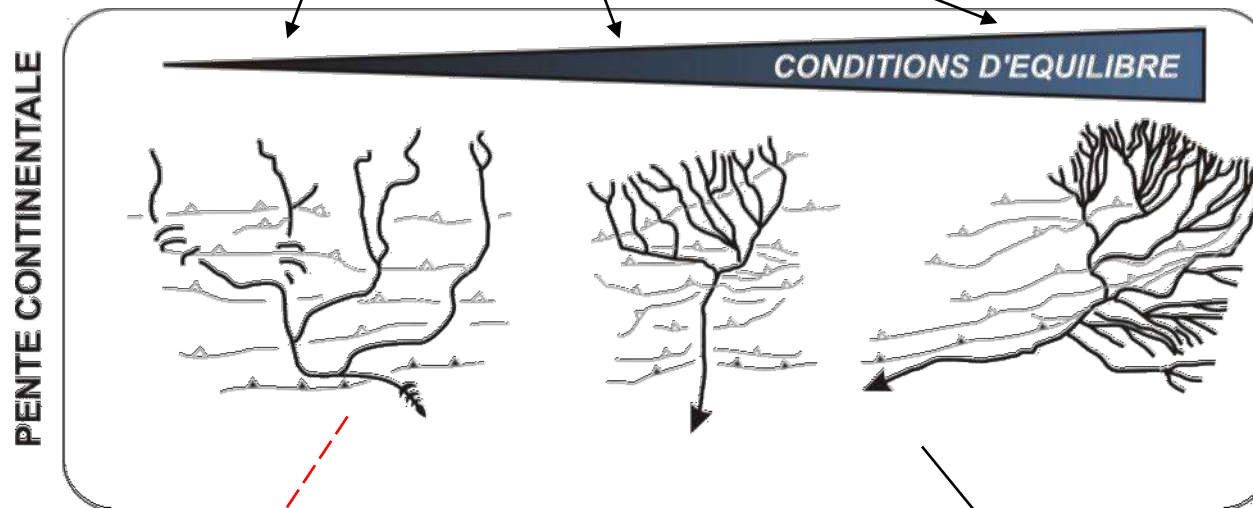
Distance (km)

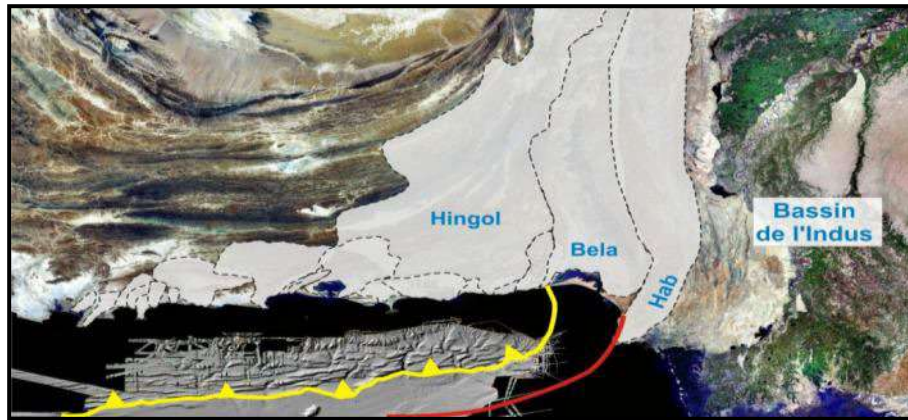




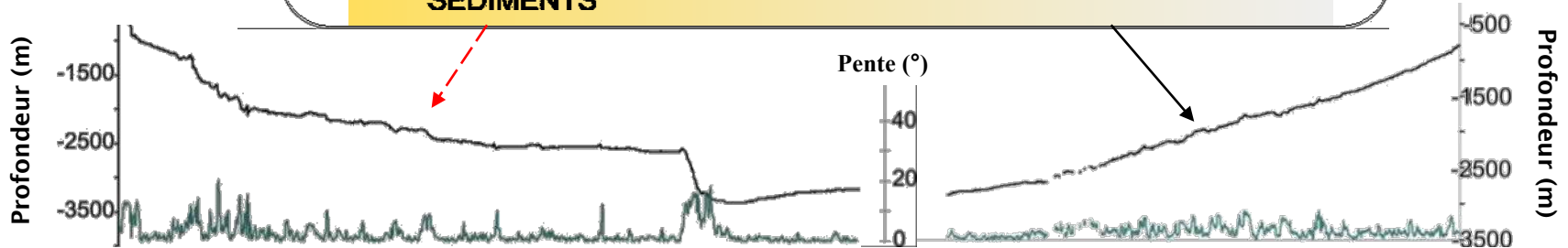
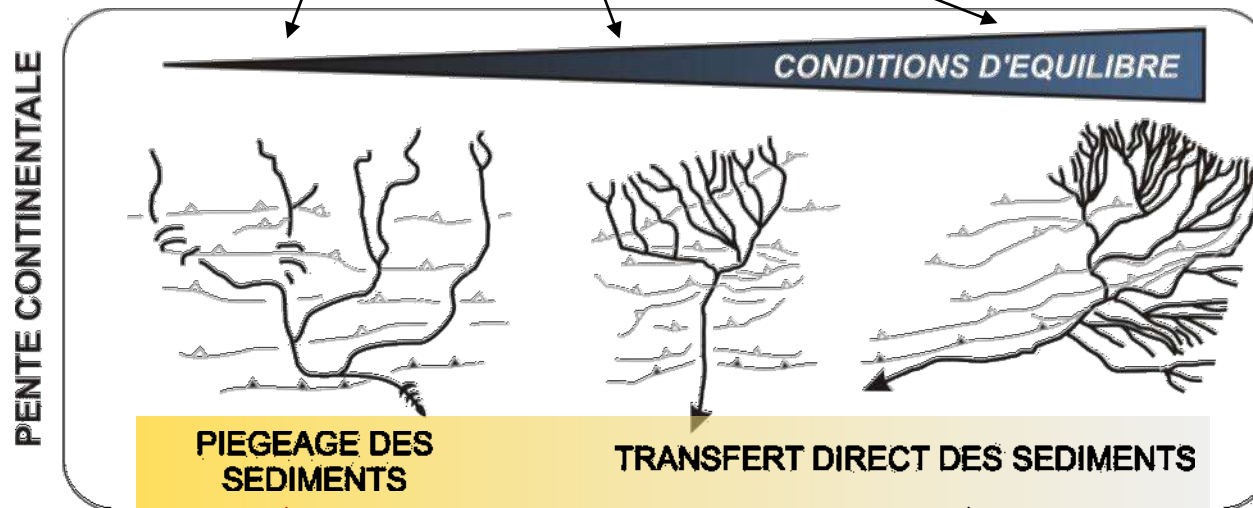


Bourget 2009

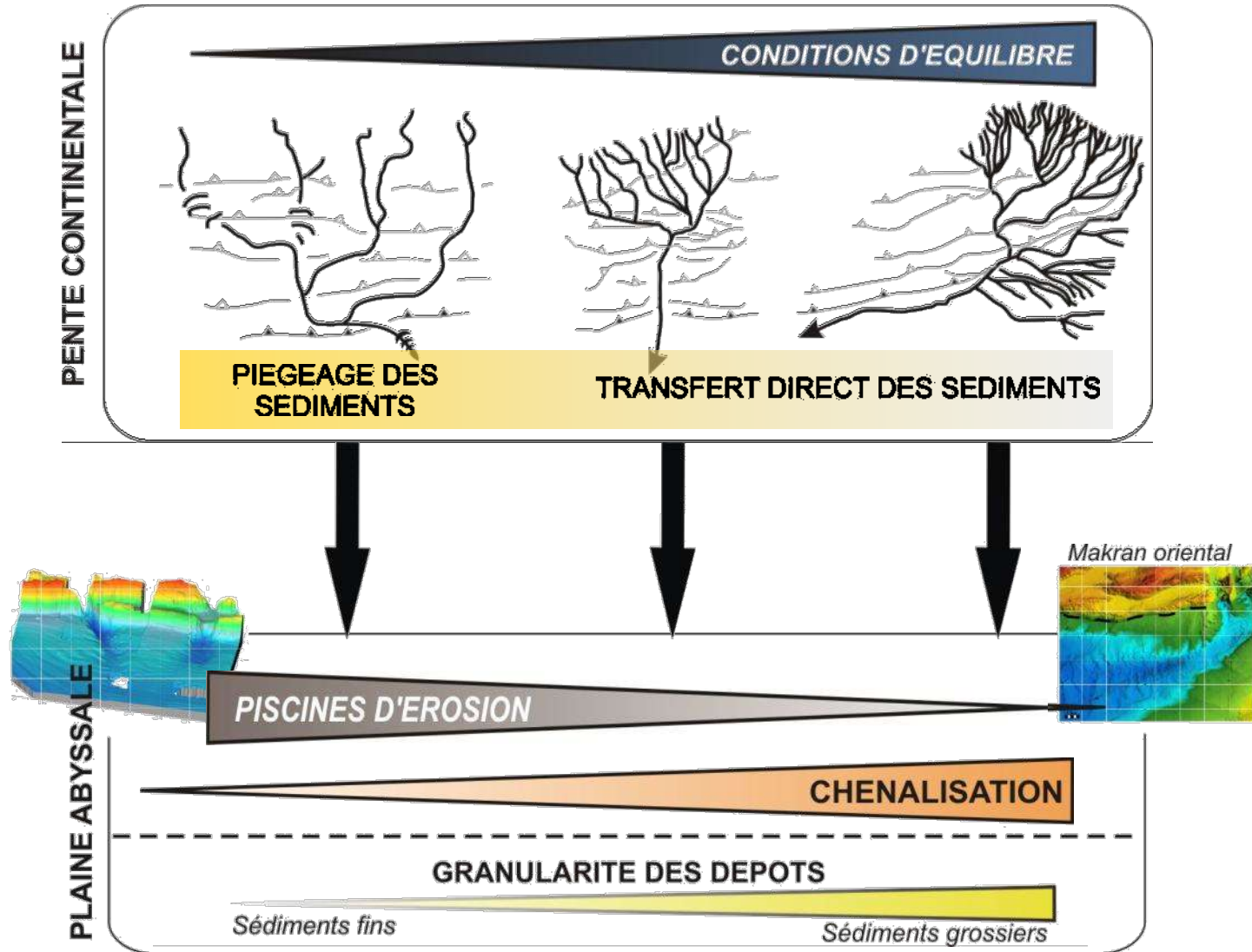




Bourget 2009



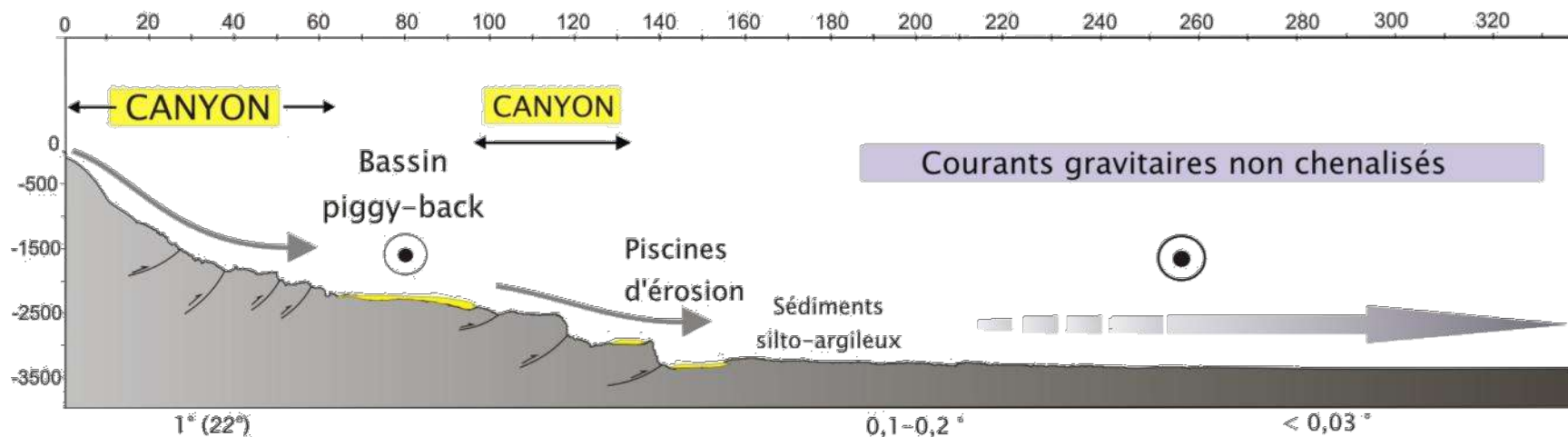




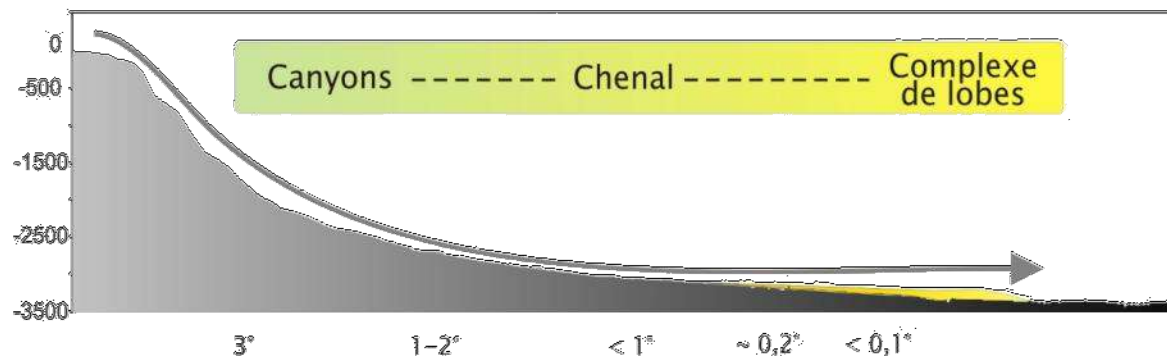
Bourget 2009

## MAKRAN (déformation active)

Distance du rebord de plateforme continentale (km)

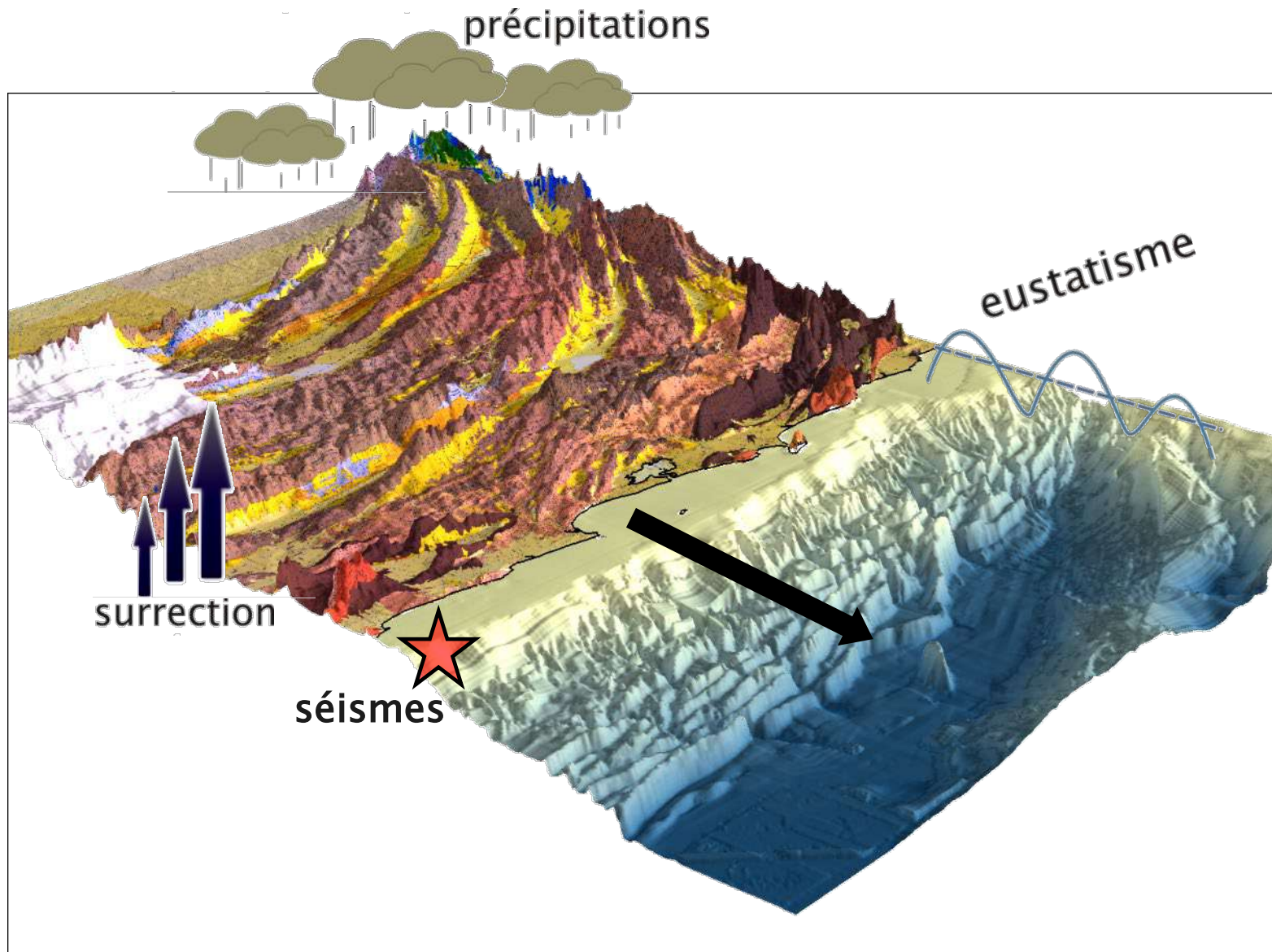


## OMAN (absence de déformation récente)

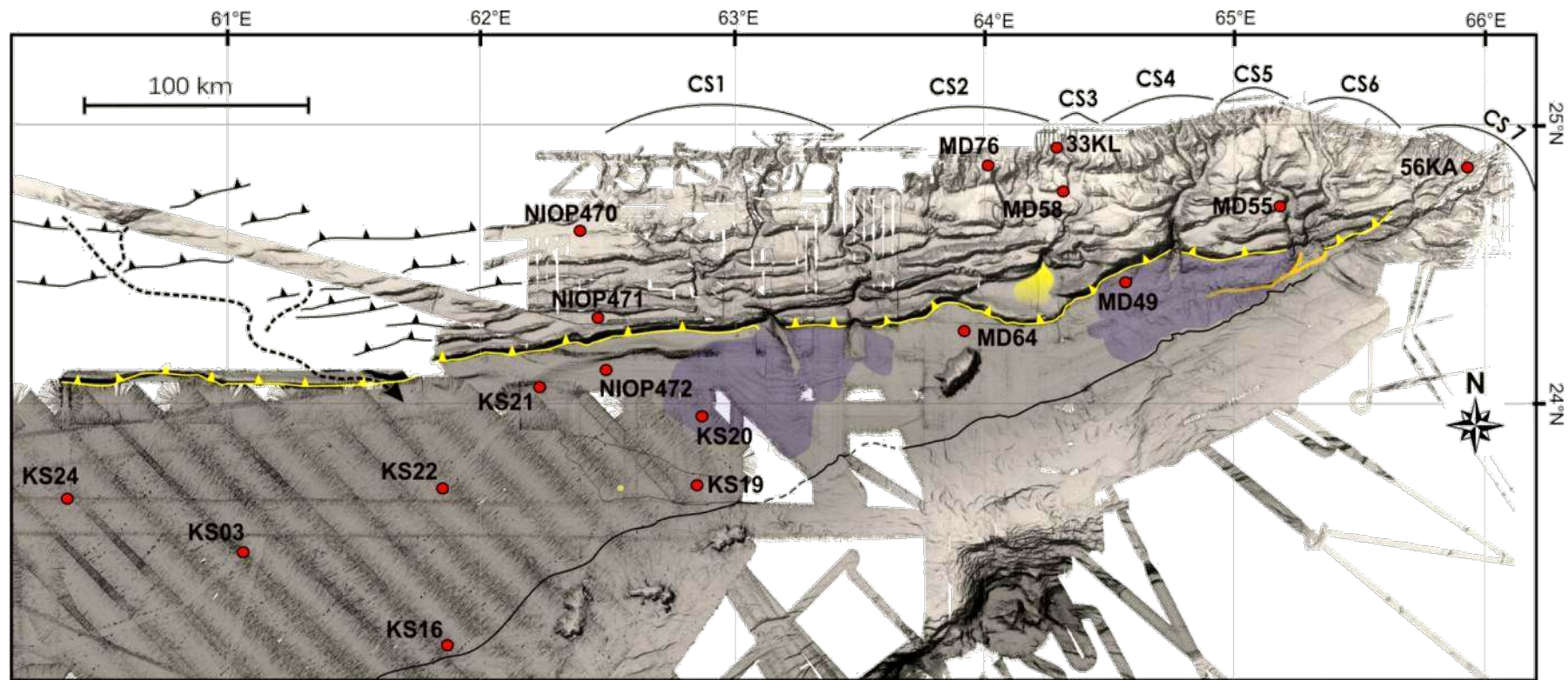


Bourget 2009



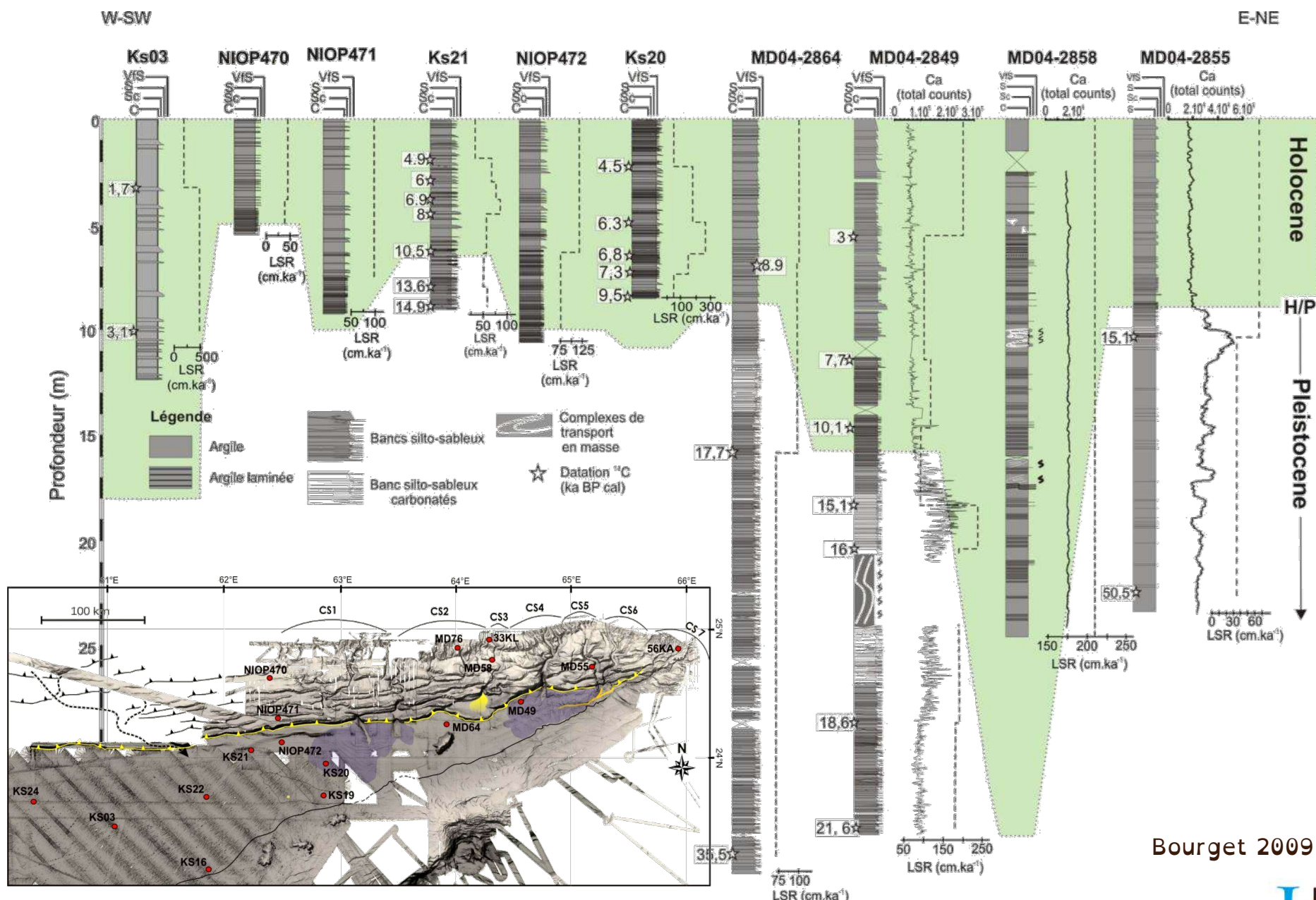


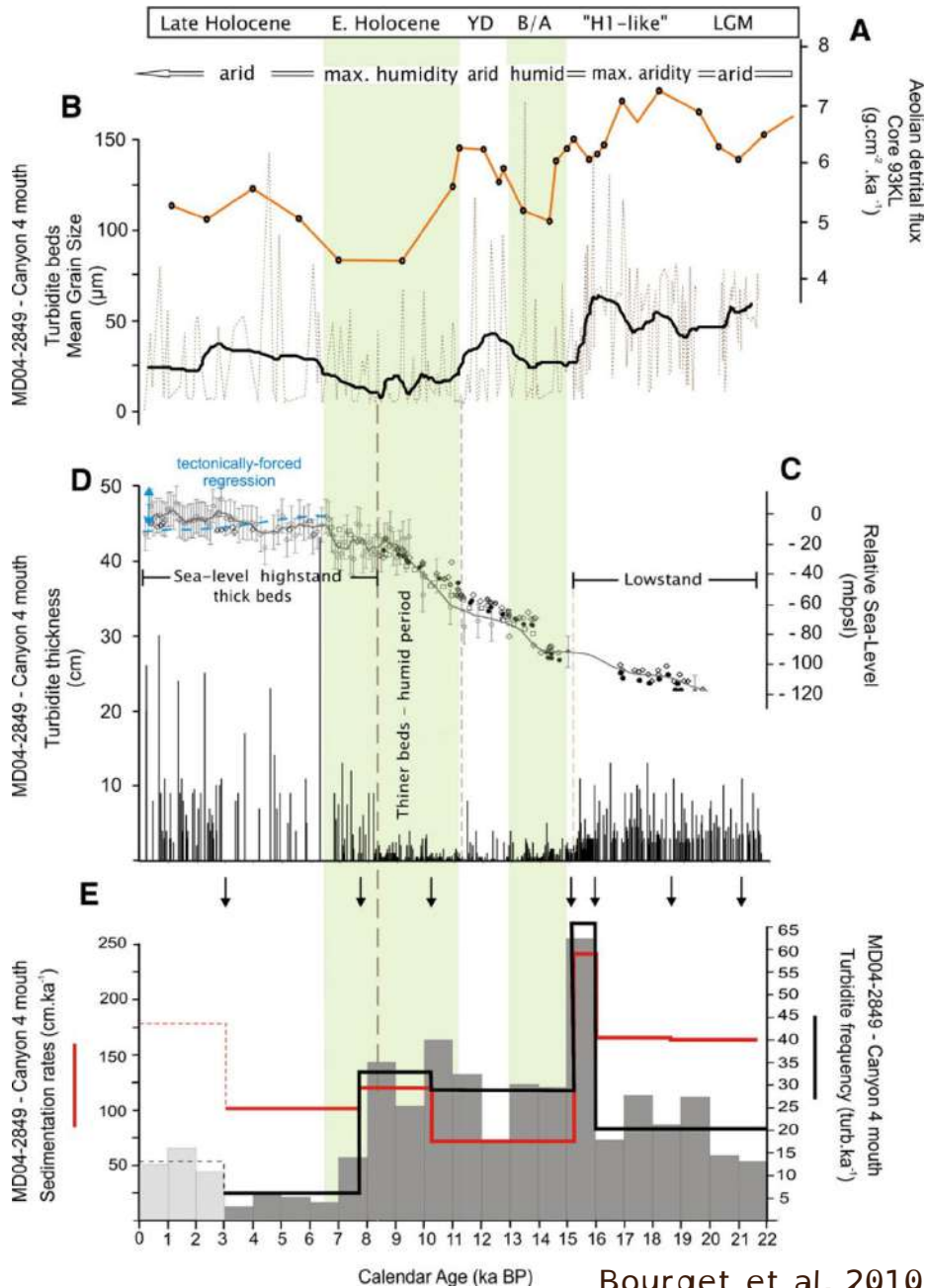
Bourget 2009



Bourget, J., Zaragosi, S., Ellouz-Zimmermann, S., Ducassou, E., Prins, M. A., Garlan, T., et al. (2010). Highstand vs. lowstand turbidite system growth in the makran active margin: Imprints of high-frequency external controls on sediment delivery mechanisms to deep water systems. *Marine Geology*, 274(1-4), 187-208.



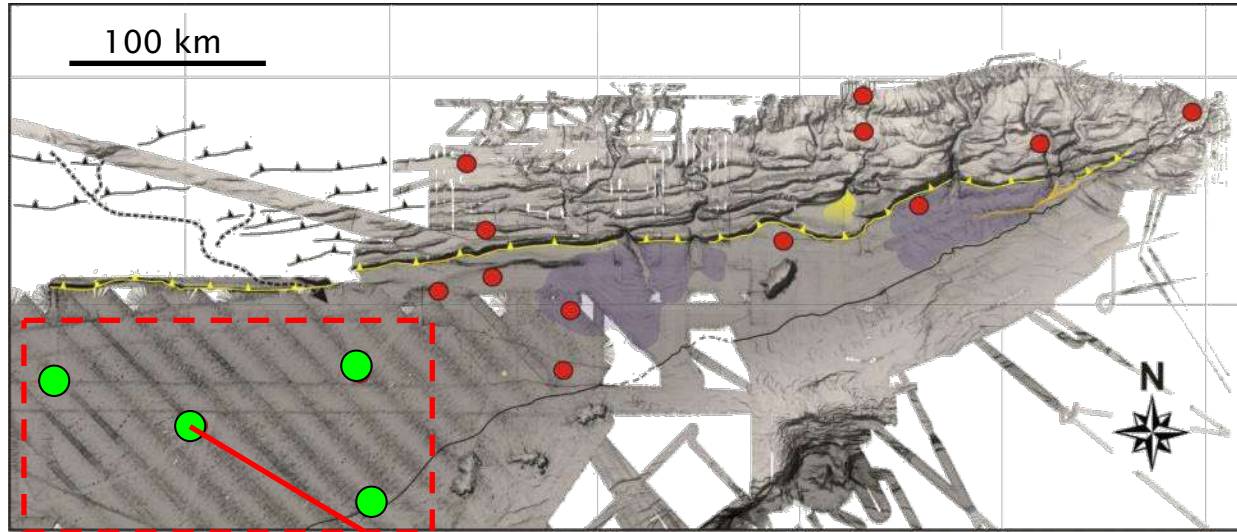




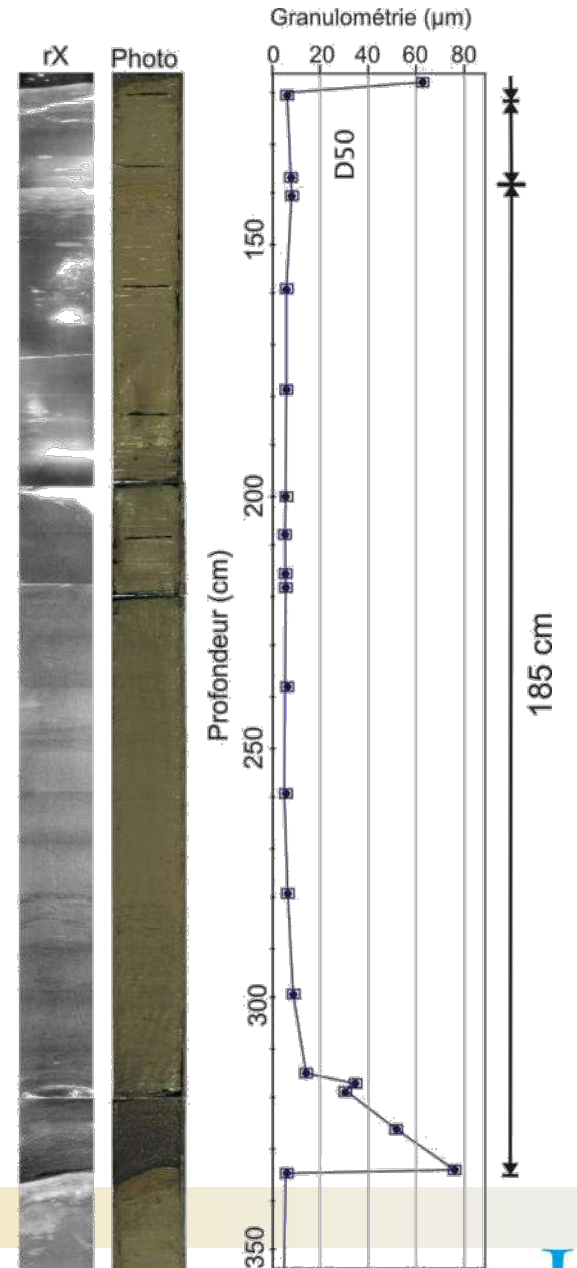
Bourget et al. 2010



MAKRAN OCCIDENTAL



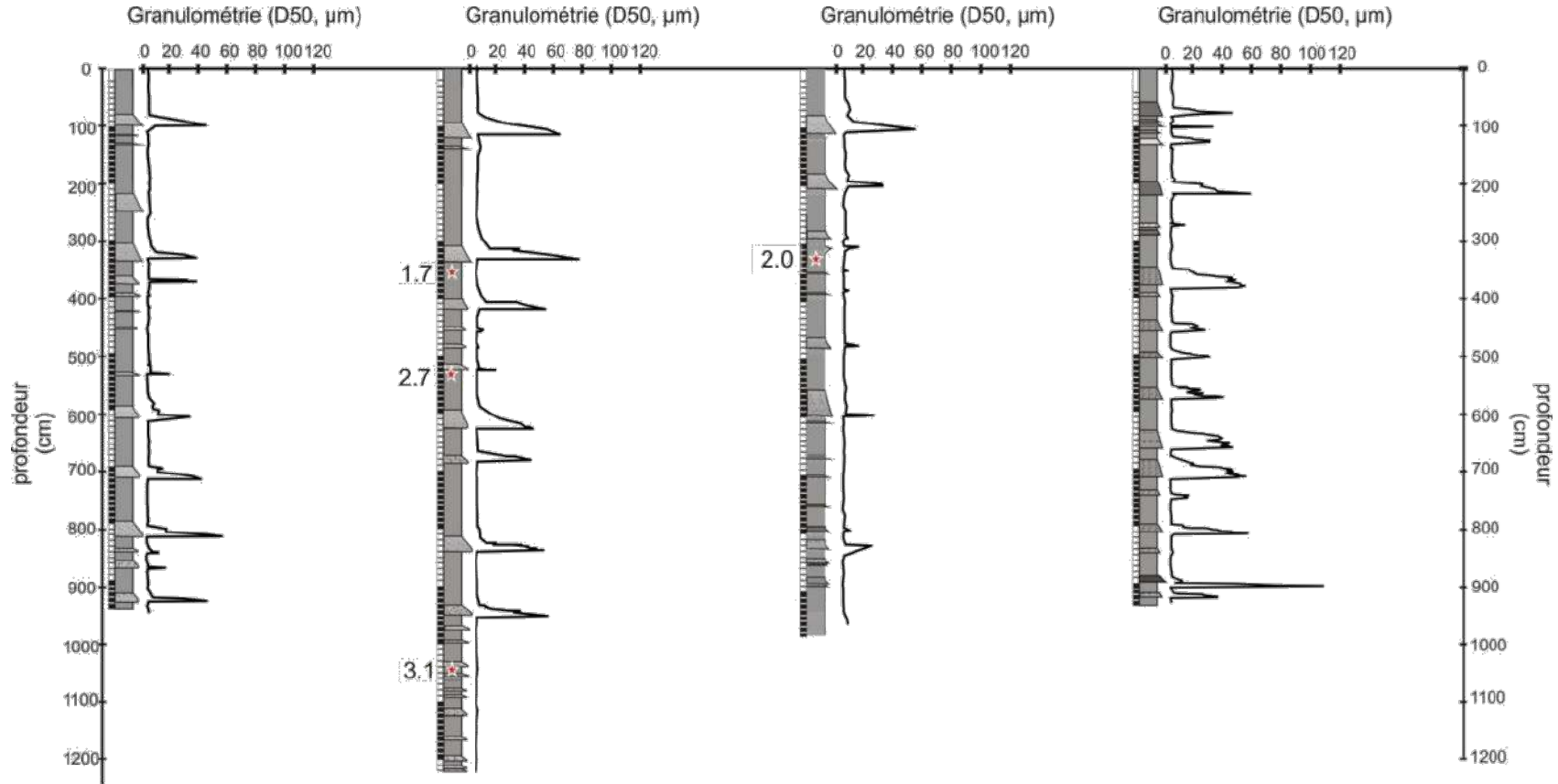
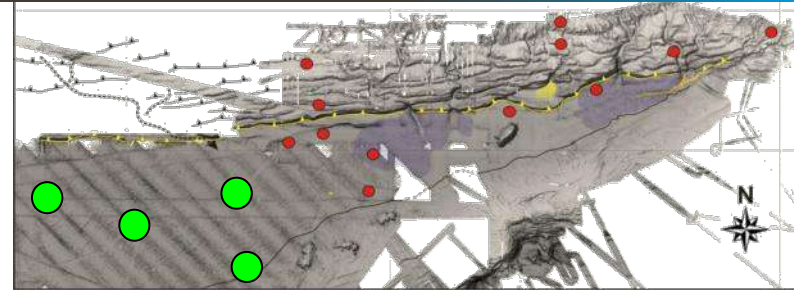
Bourget 2009



Séquences turbiditiques argilo-silteuses holocènes sup.



## MAKRAN OCCIDENTAL



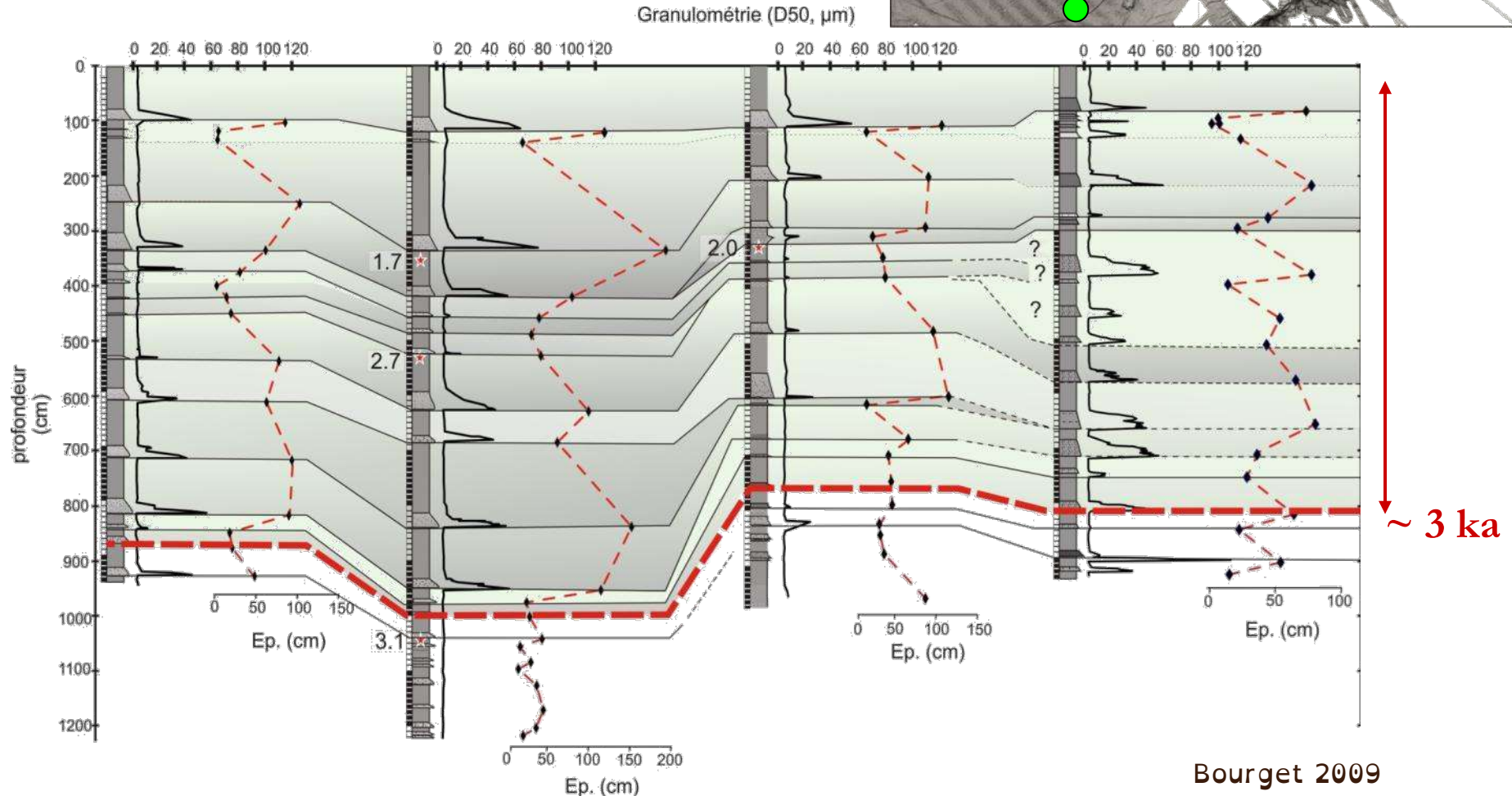
Bourget 2009

Séquences turbiditiques argilo-silteuses holocènes sup.

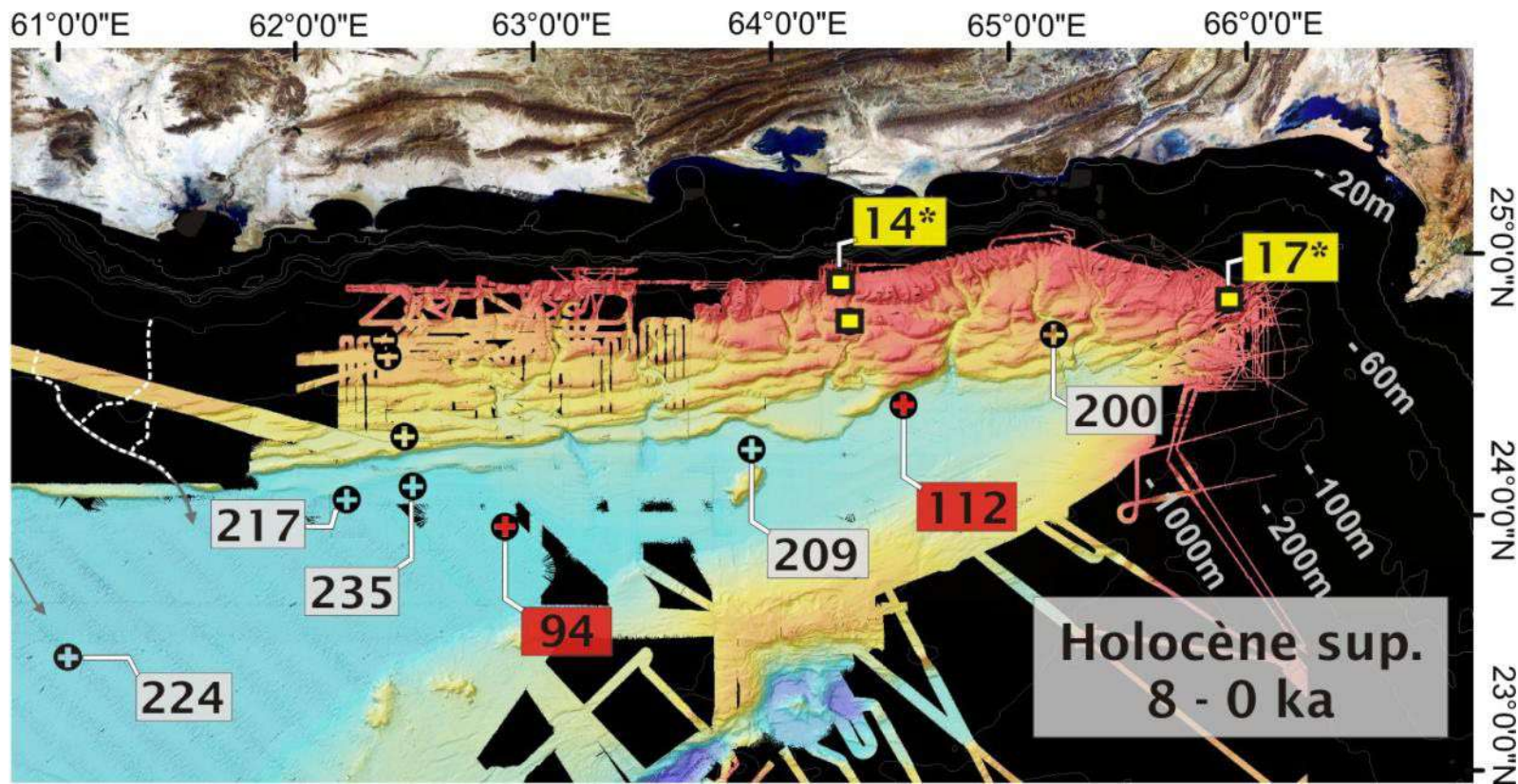






## MAKRAN OCCIDENTAL



Écoulements drappants (non chenalisés) volumineux – haut niveau marin relatif

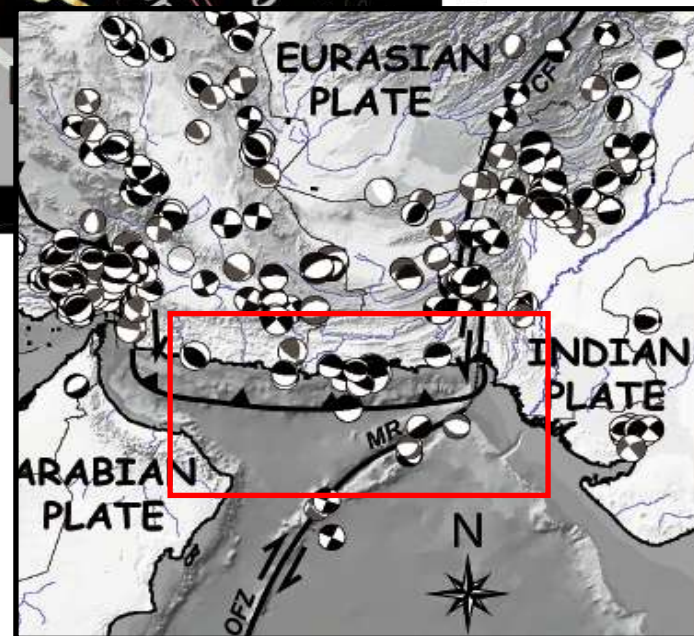
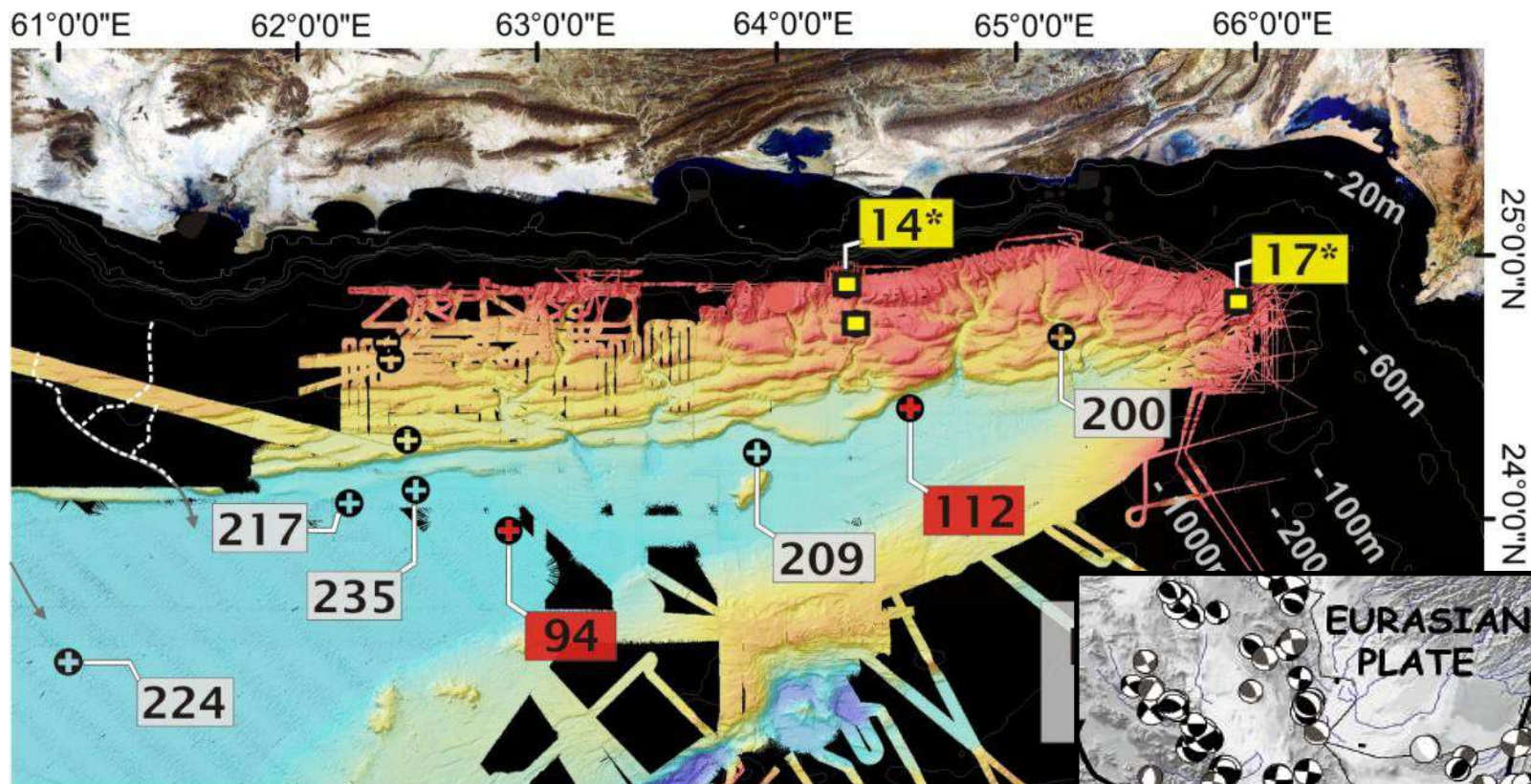


## TEMPS DE RECURRENCE (années)

-  ~ 100 ans dans les axes des canyons
-  ~ 200 / 250 ans dans le reste du bassin

~ 15 ans dans la pente continentale supérieure

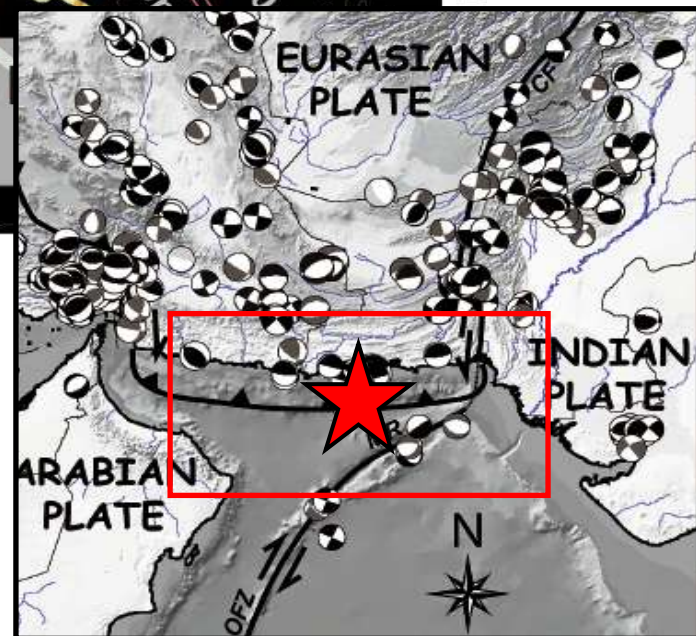
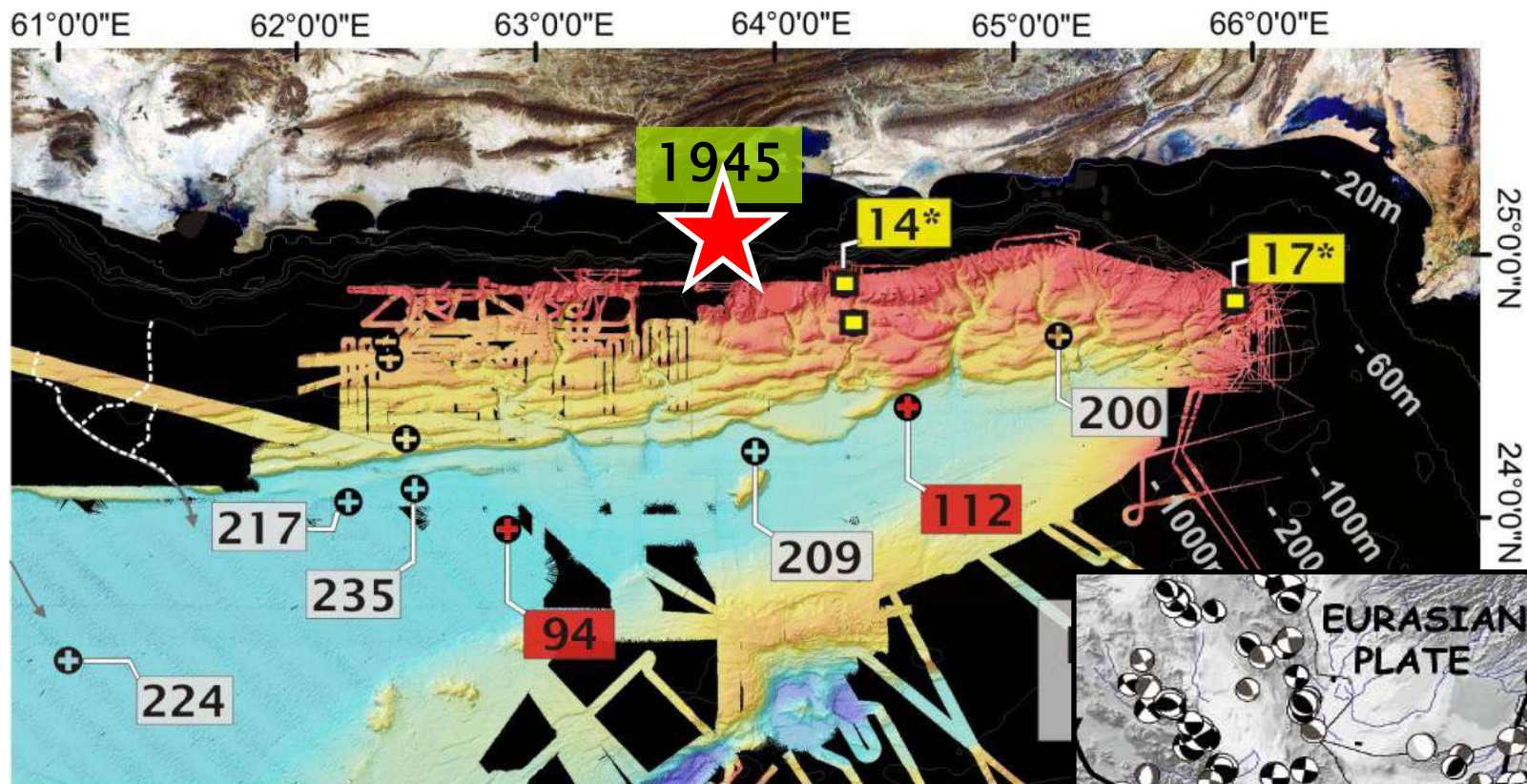






Temps de récurrence 200 – 235 ans  
= grands séismes historiques / tsunamis

Ambrasseys & Melville, 1982; Byrne et al., 1992;  
Ambrasseys & Bilham, 2003; Heidarzadeh et al., 2009

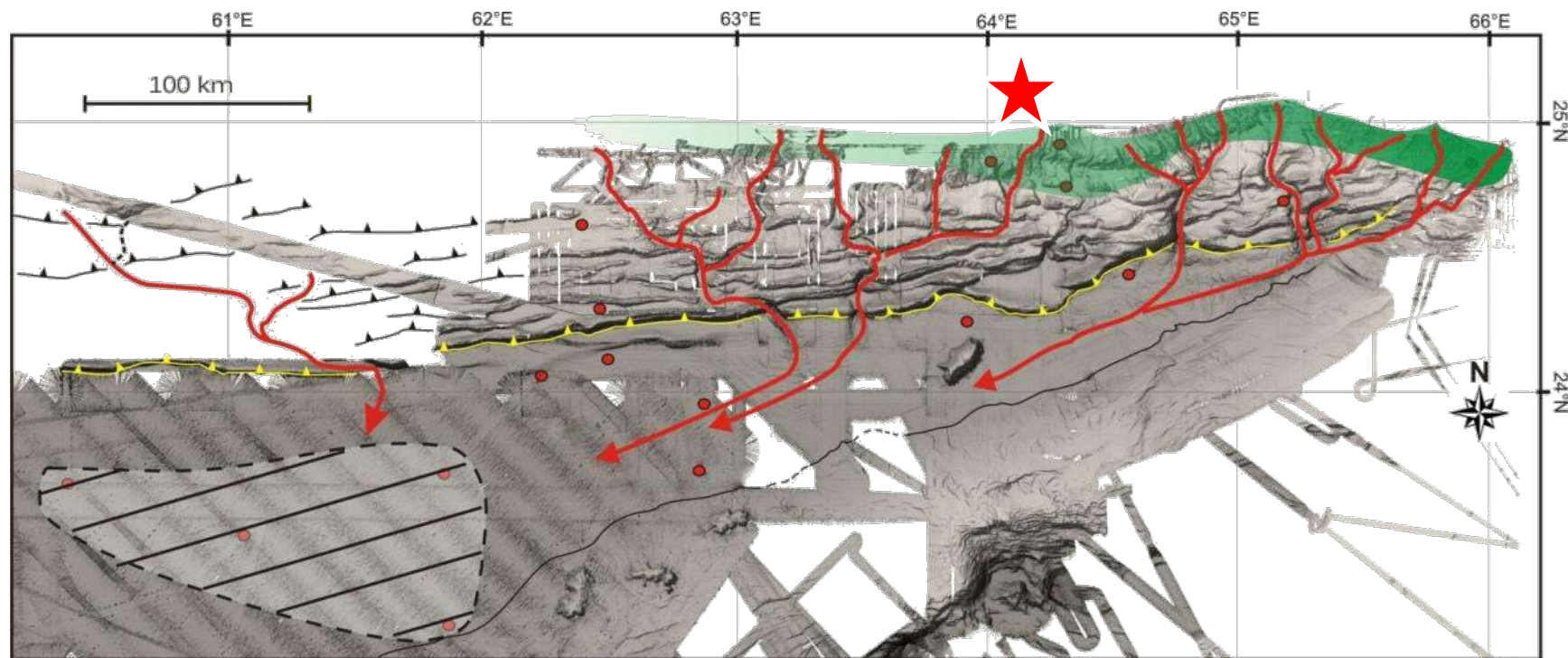




Séisme 1945 ( $M_8$ )

-  écoulement(s) gravitaire(s)
-  plusieurs glissements sous-marins



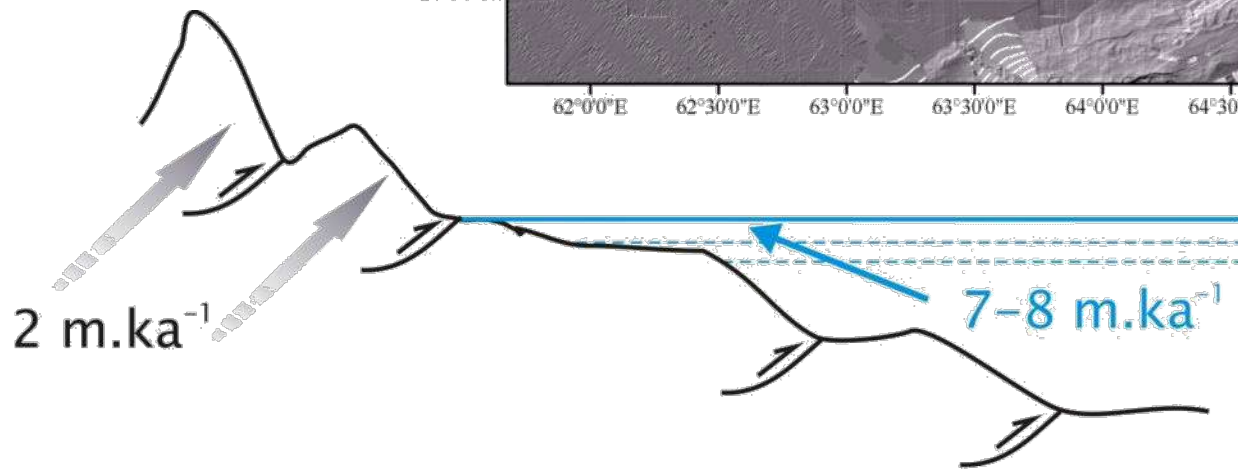
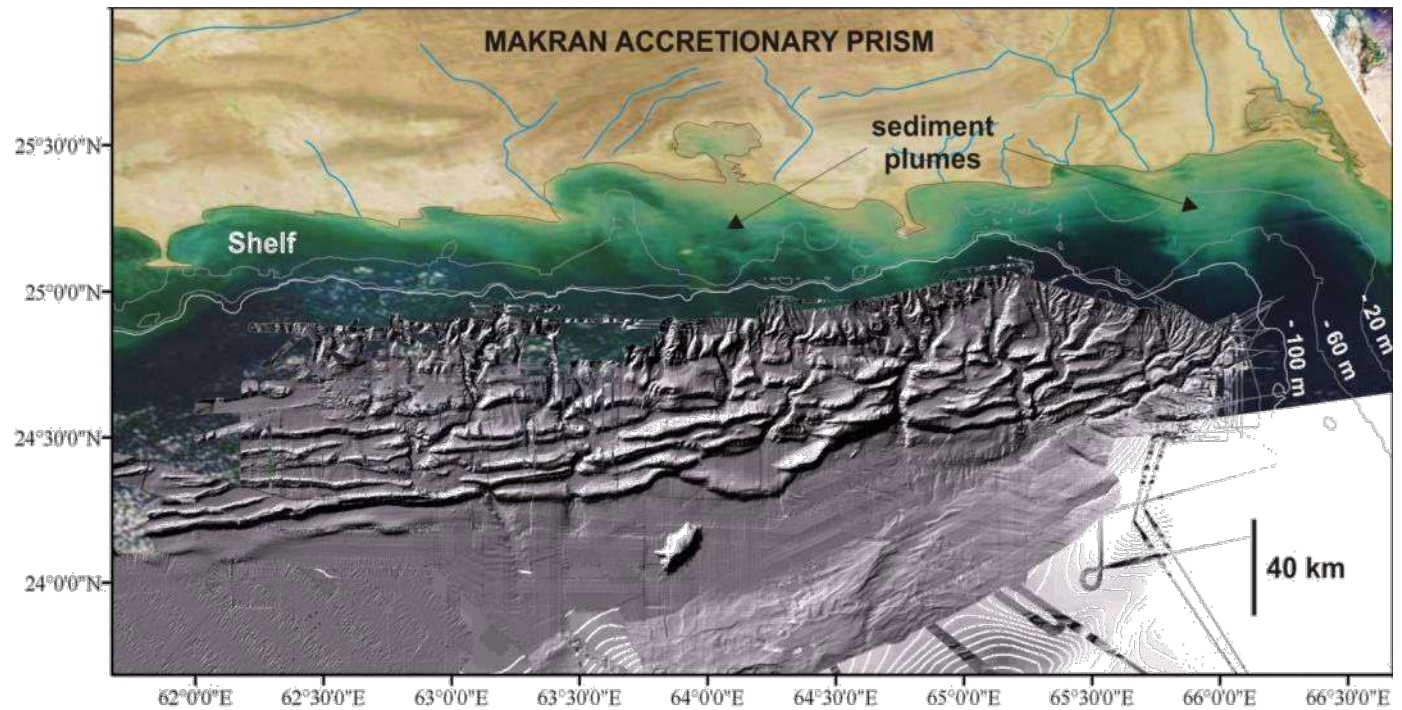


Ecoulements très volumineux, riches en vase :

➡ déstabilisations co-sismiques des sédiments accumulés dans la pente continentale supérieure

Bourget 2009

**Ecoulements synchrones multisources – convergence dans le bassin distal**

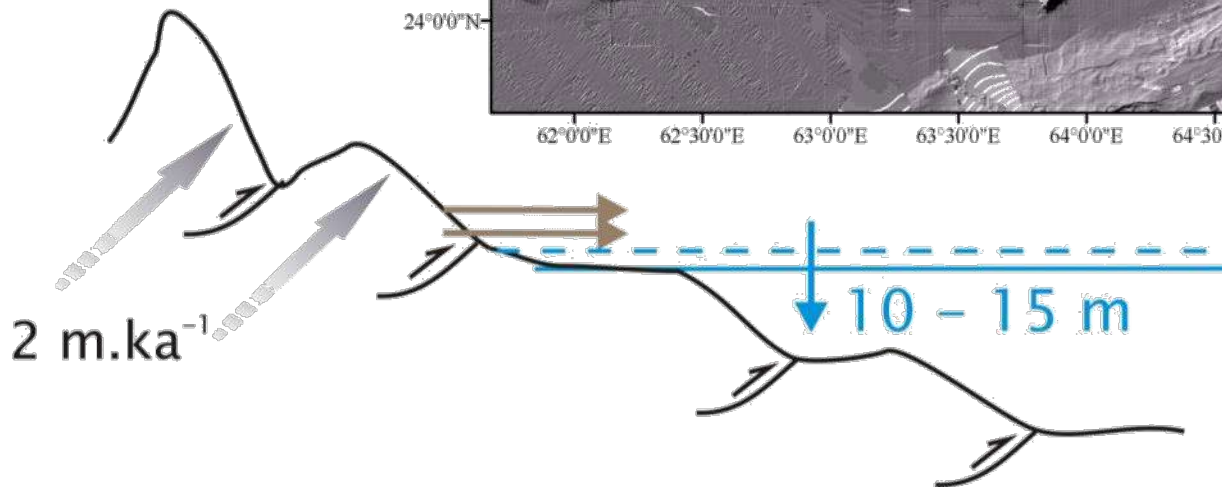
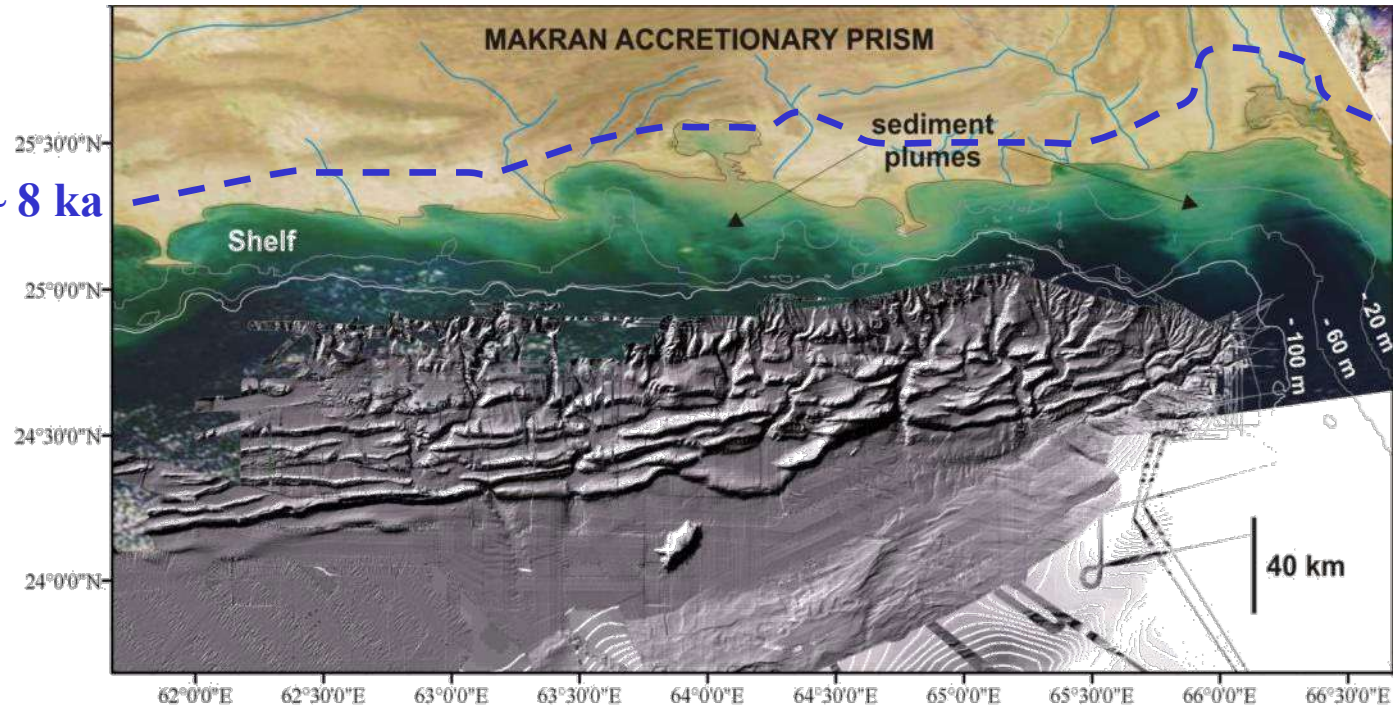


Transgression post-glaciaire (22 – 8 ka BP)

Bourget 2009



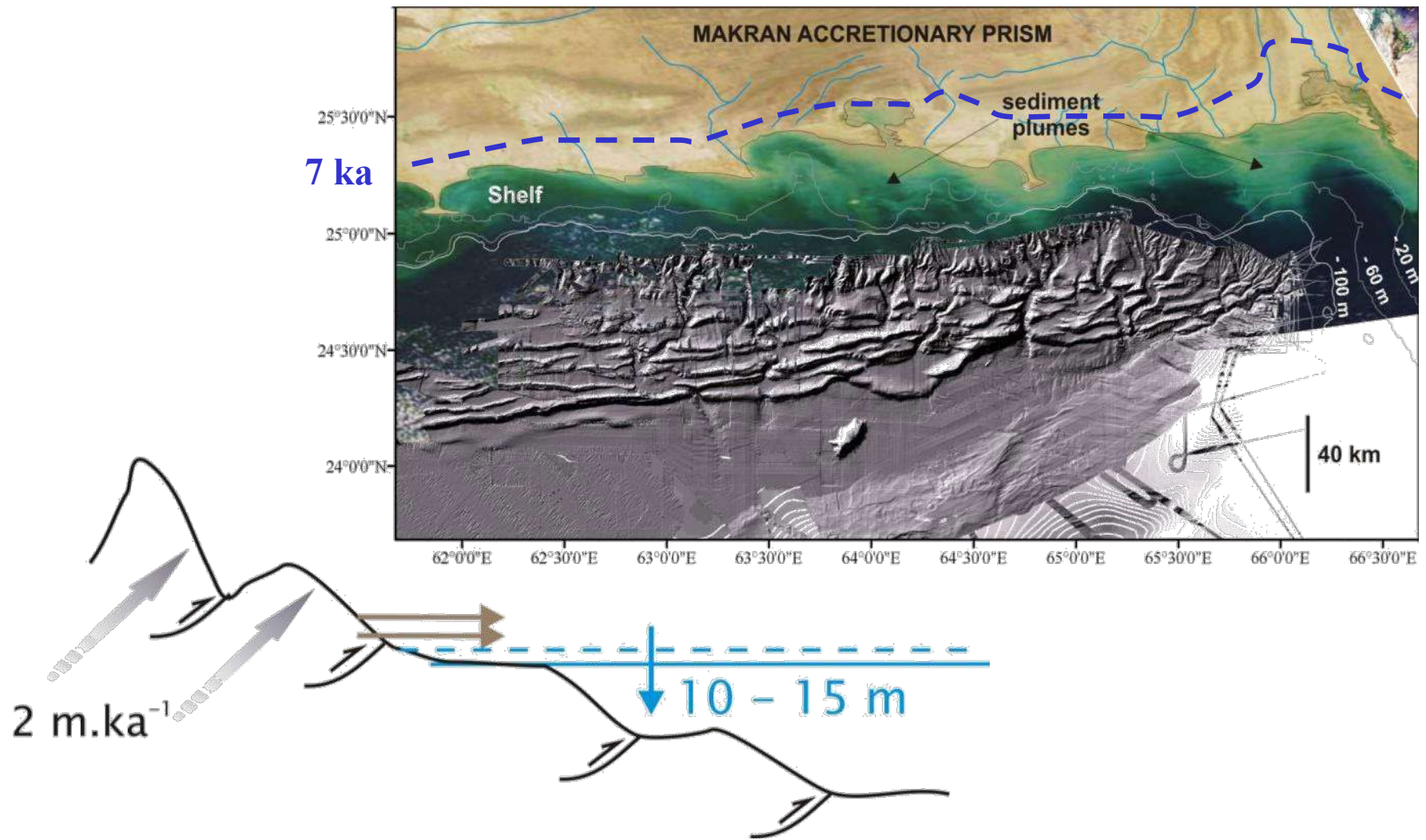
Trait de côte à ~ 8 ka



Bourget 2009

Surrection des reliefs continentaux : progradation de la marge à l'Holocène sup.

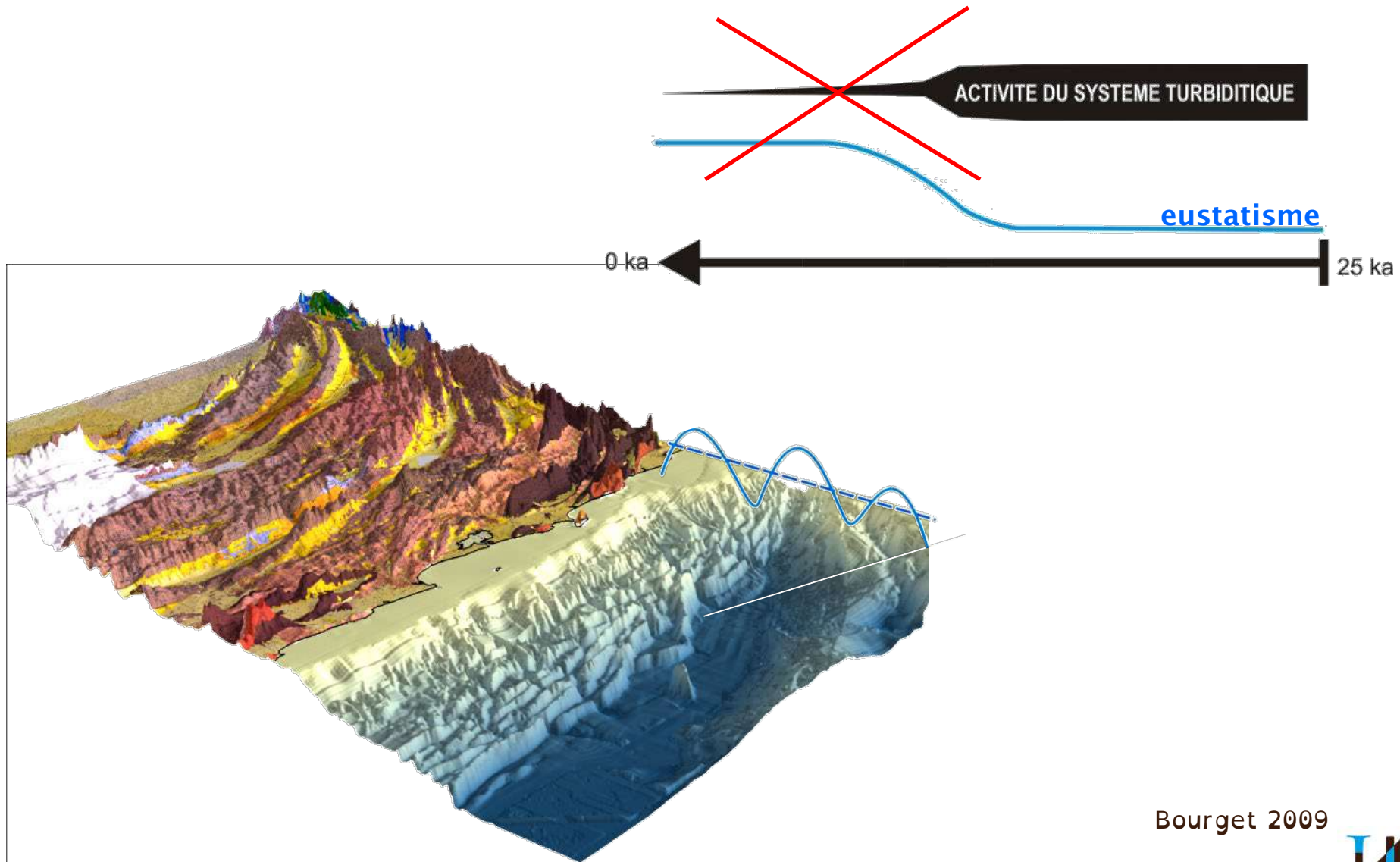




Bourget 2009

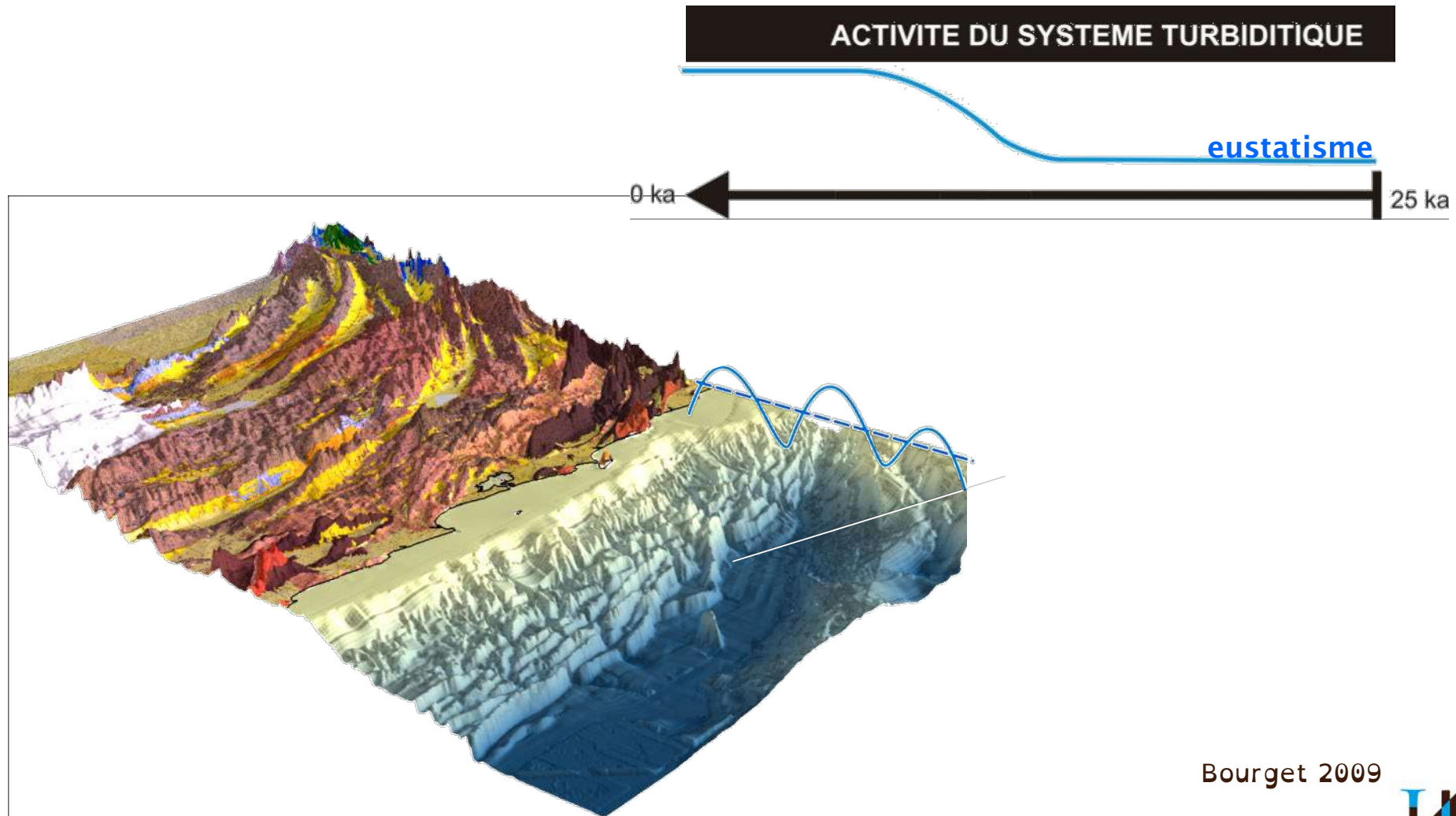
**Surrection des reliefs continentaux : progradation de la marge à l'Holocène sup.**





Bourget 2009



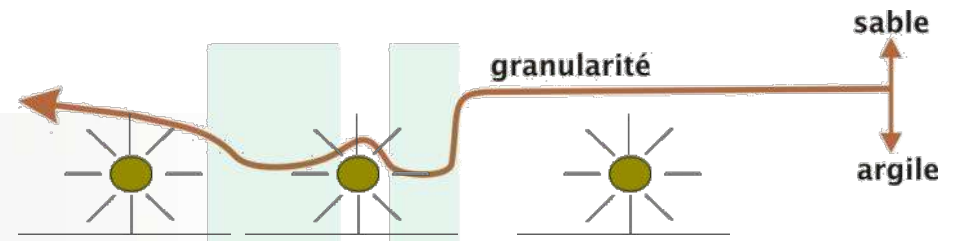


Bourget 2009

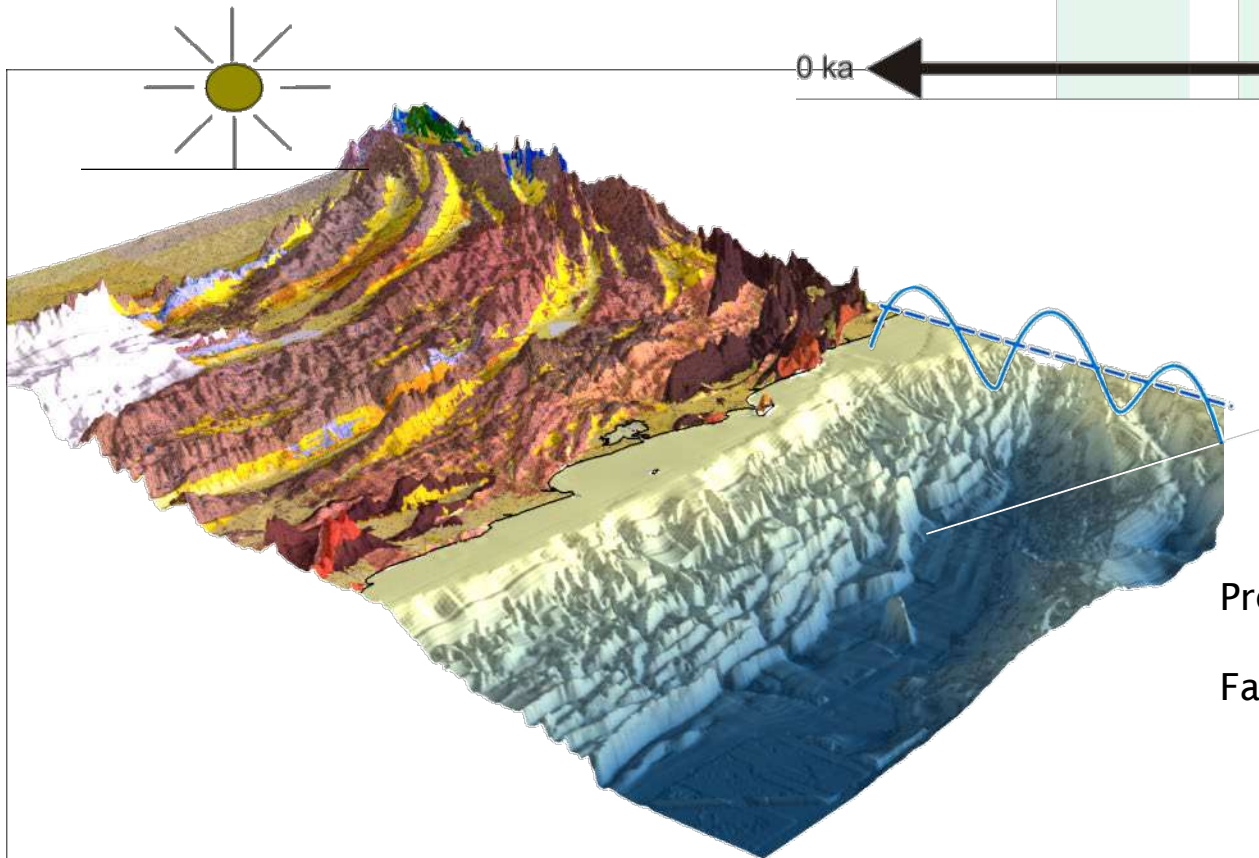
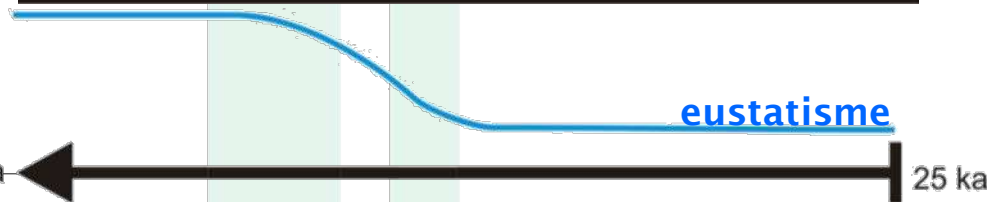


## FORÇAGE CLIMATIQUE

VARIABILITE FLUX (NATURE / FREQUENCE)



## ACTIVITE DU SYSTEME TURBIDITIQUE



## Périodes arides

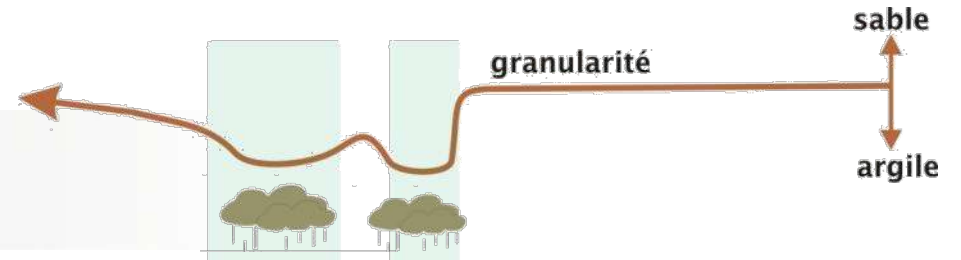
Production de sédiments grossiers

Faibles débits + éolien

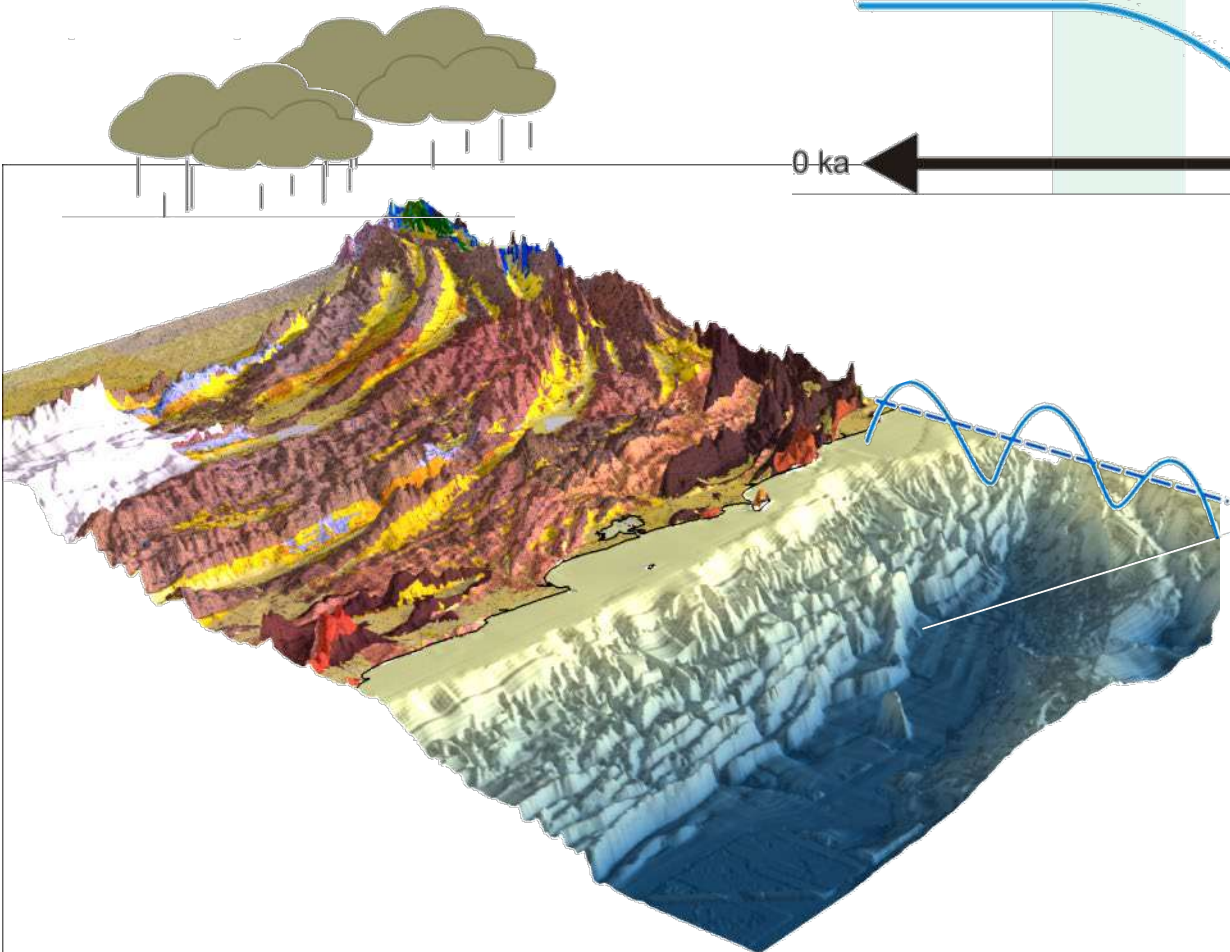
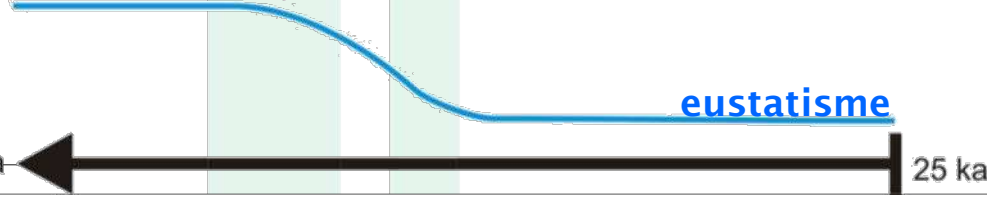
Bourget 2009

# FORÇAGE CLIMATIQUE

VARIABILITE FLUX (NATURE / FREQUENCE)



## ACTIVITE DU SYSTEME TURBIDITIQUE



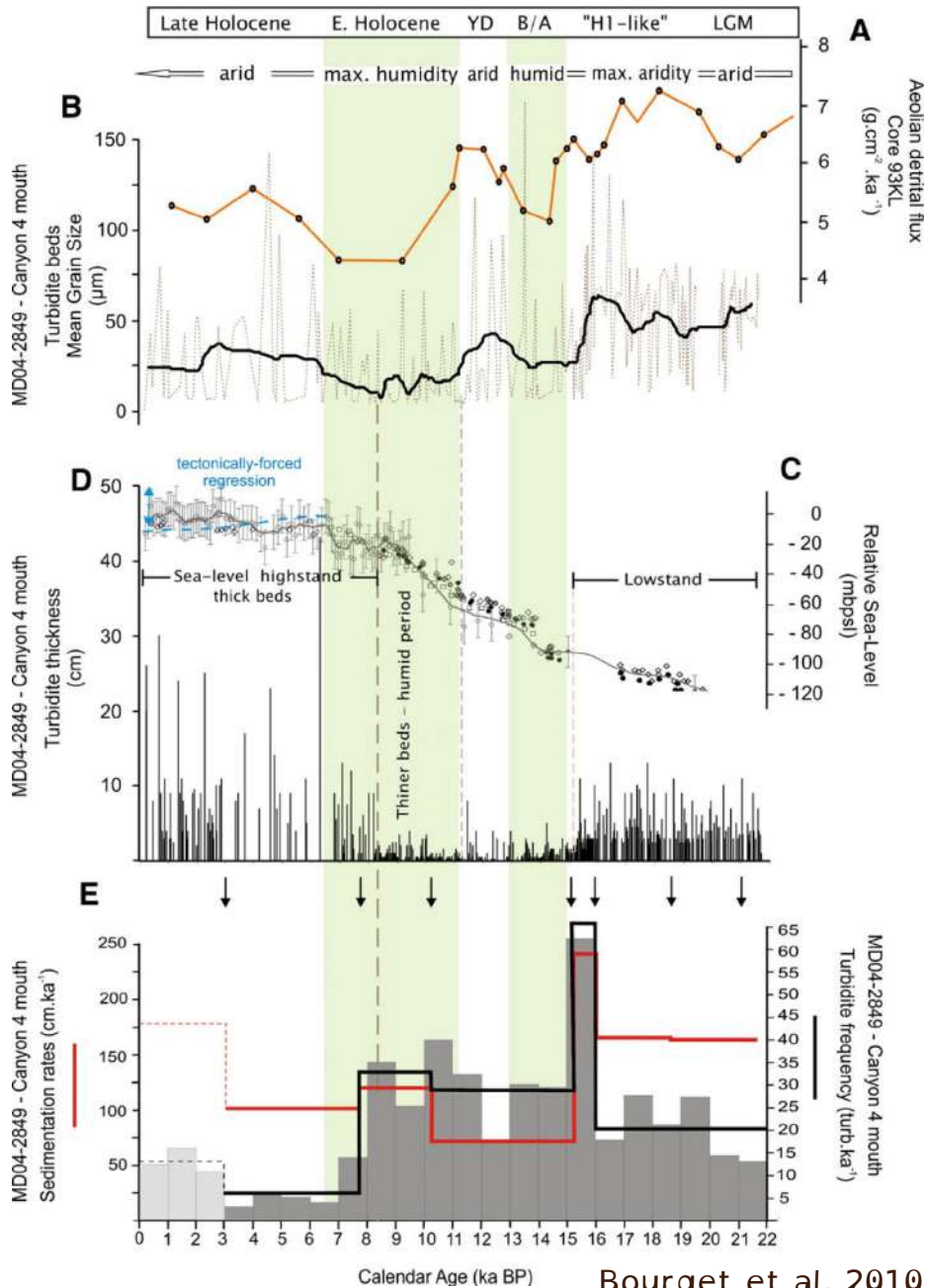
### Périodes humides

Production de sédiments fins  
→ débits, incision rivières

Bourget 2009

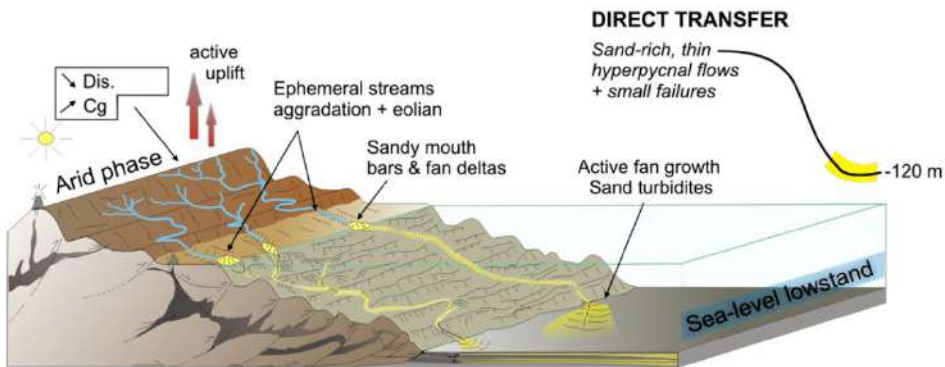
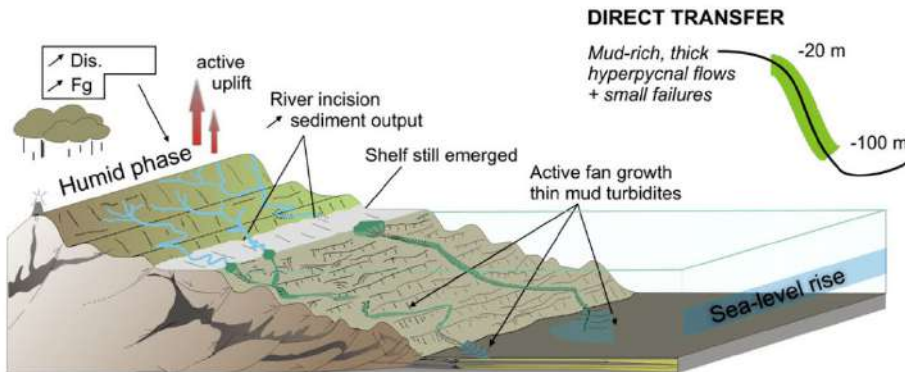
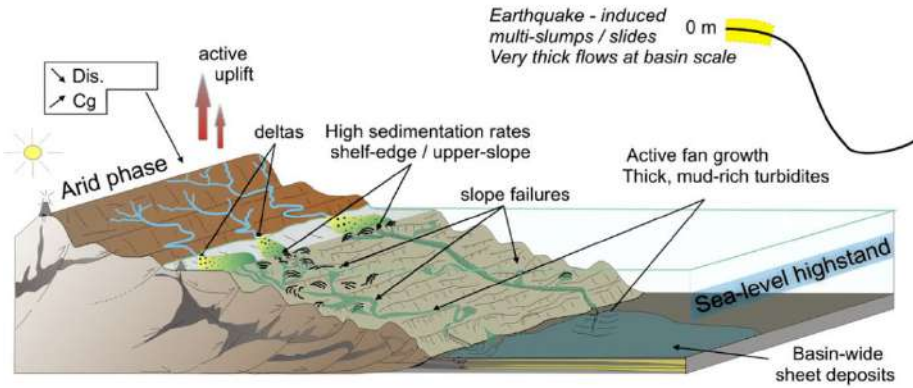






Bourget et al. 2010

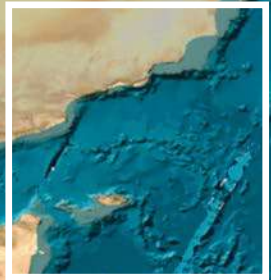
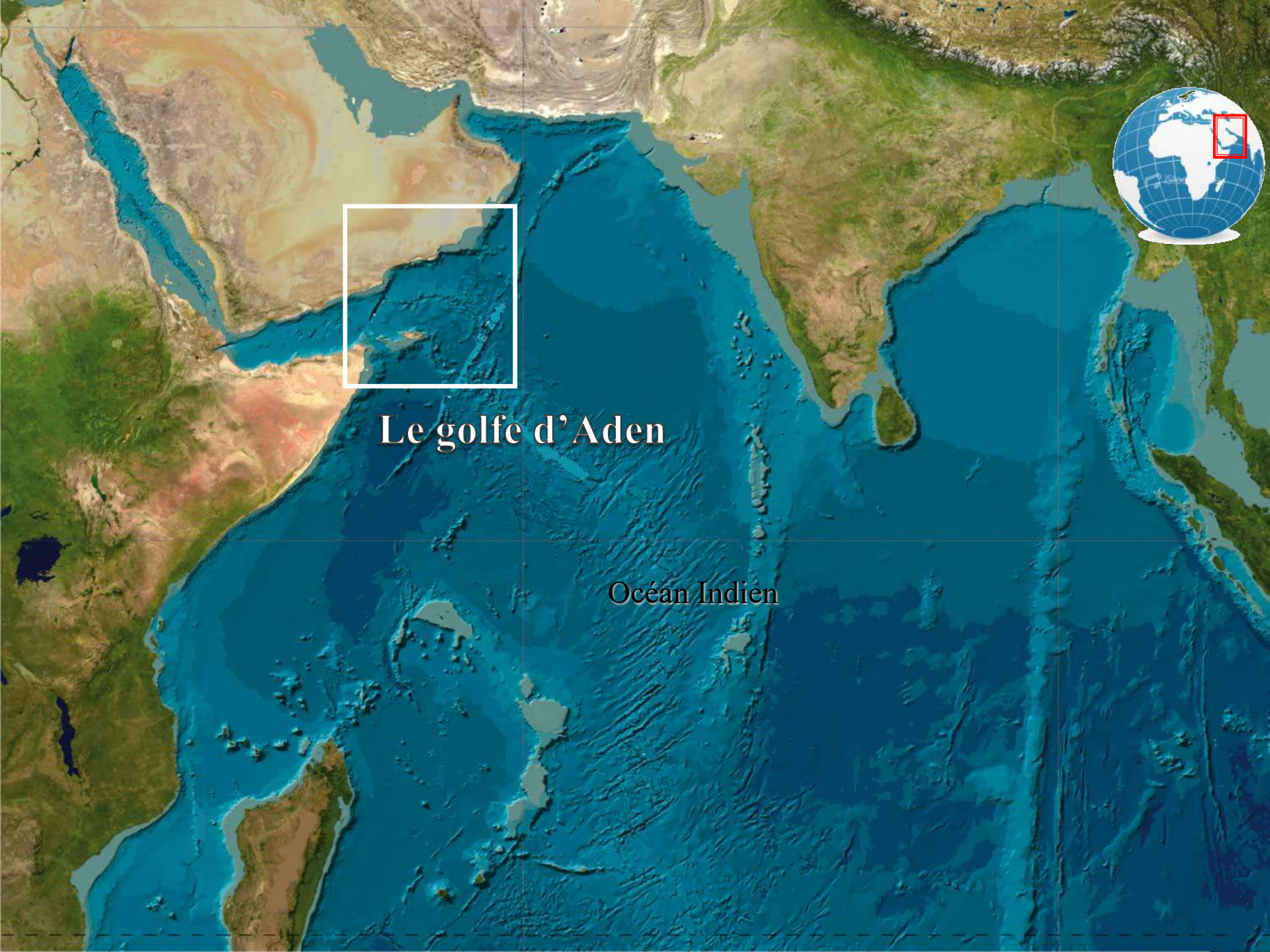
## SEDIMENT STORAGE - MASS WASTING EVENTS



Dis. = Fluvial discharge  
Cg. = Production of coarse-grained material  
Fg. = Production of fine-grained material

Bourget et al. 2011





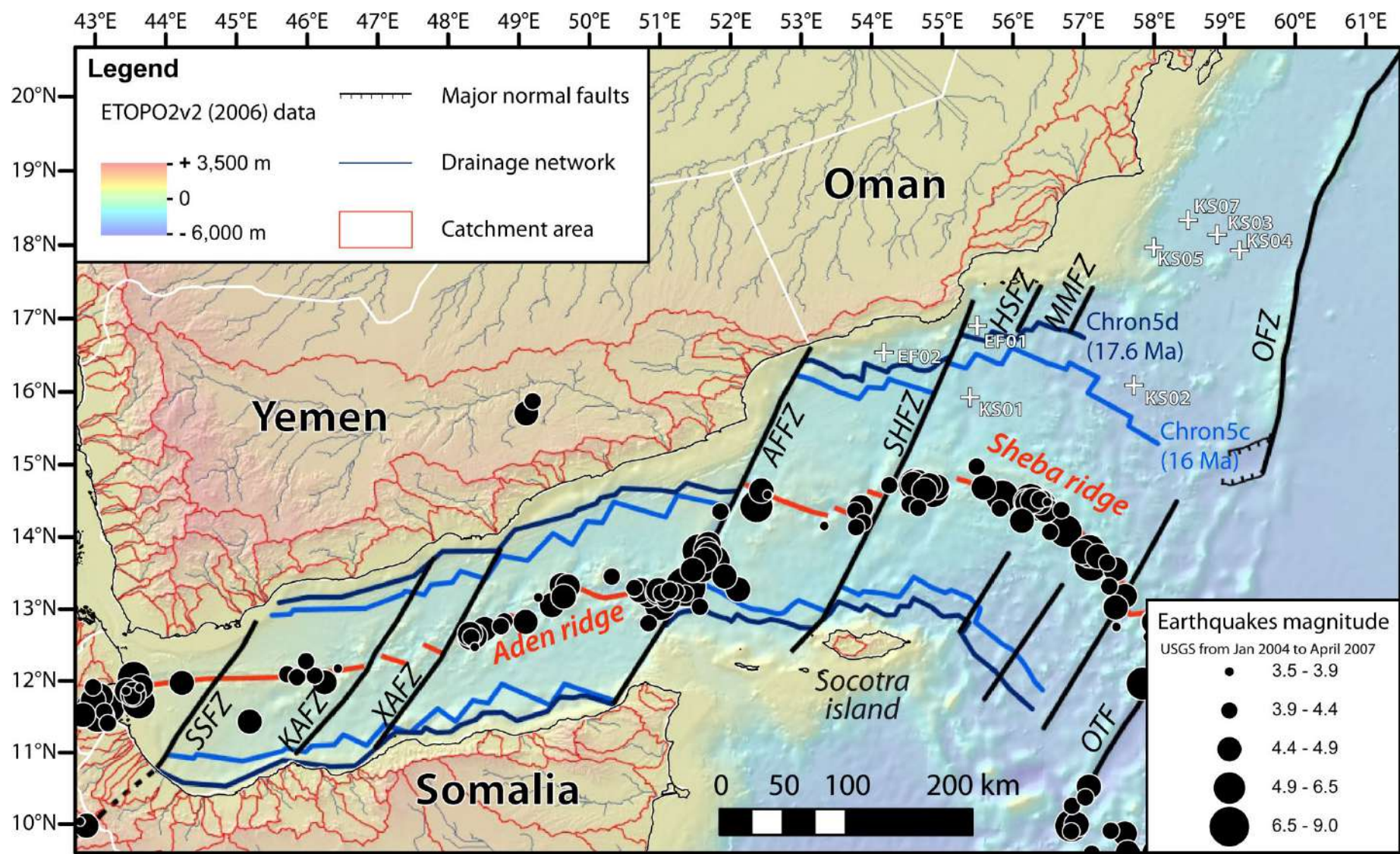
Le golfe d'Aden

Océan Indien





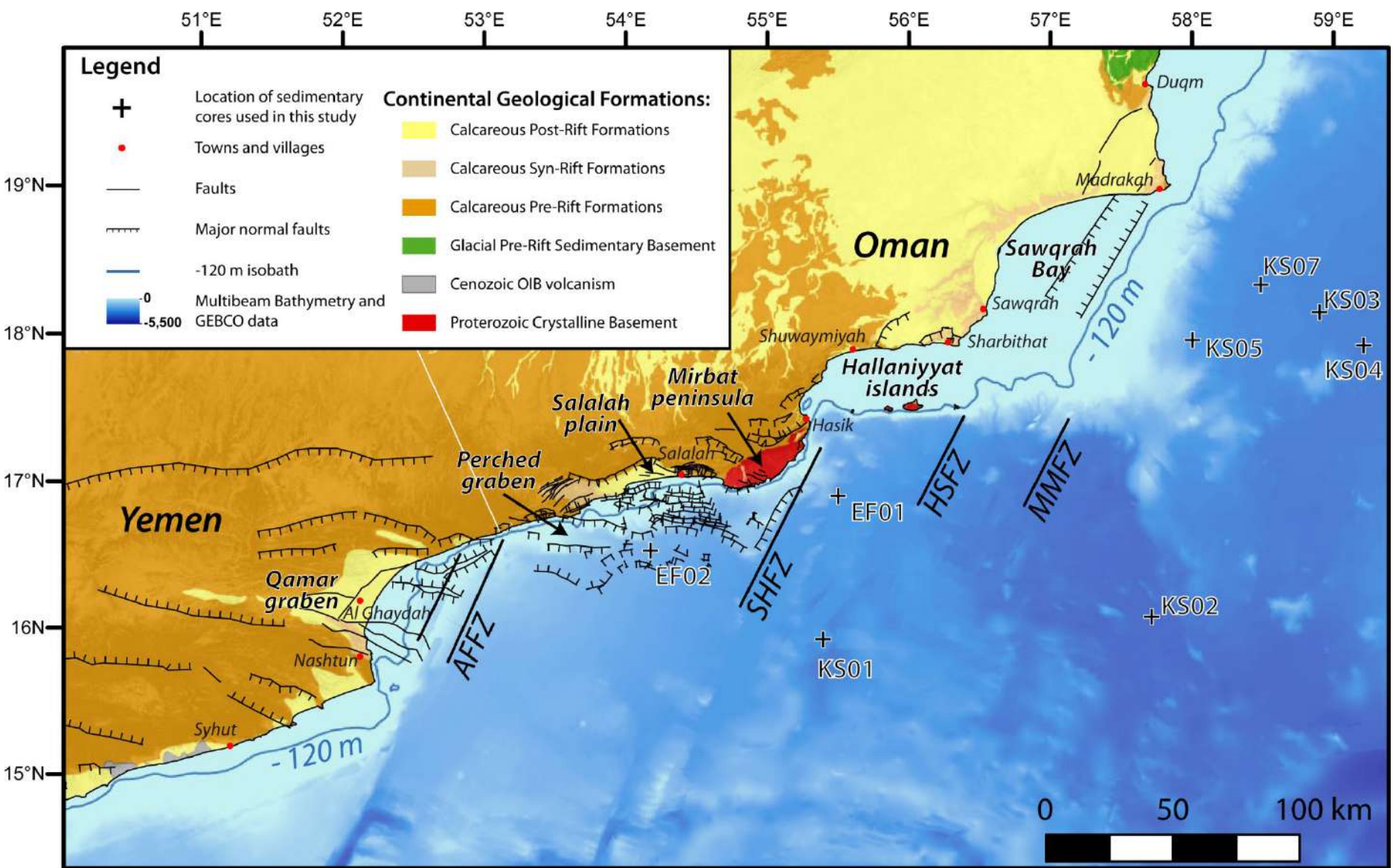
# Le golfe d'Aden



Baurion 2012

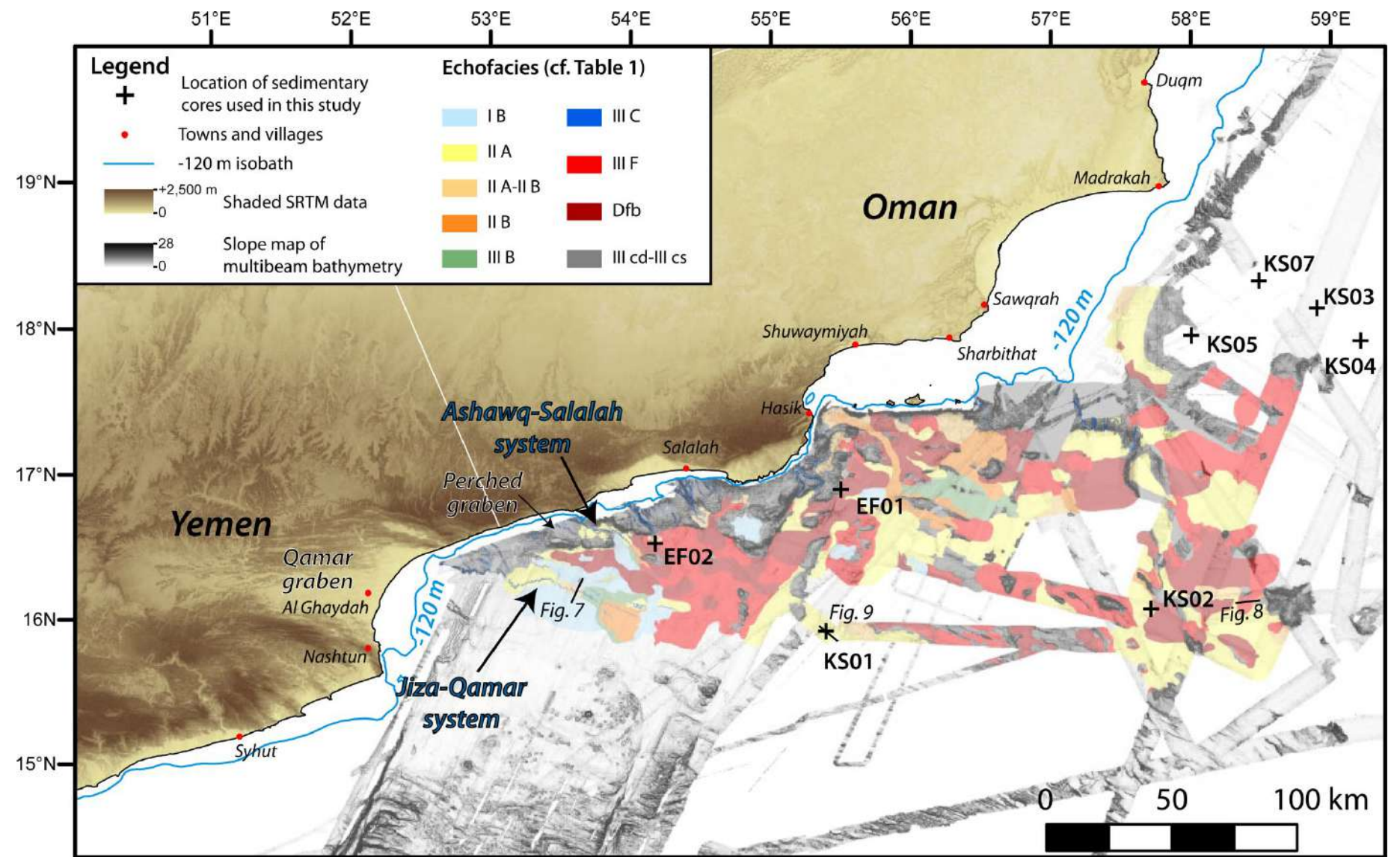






Baurion 2012

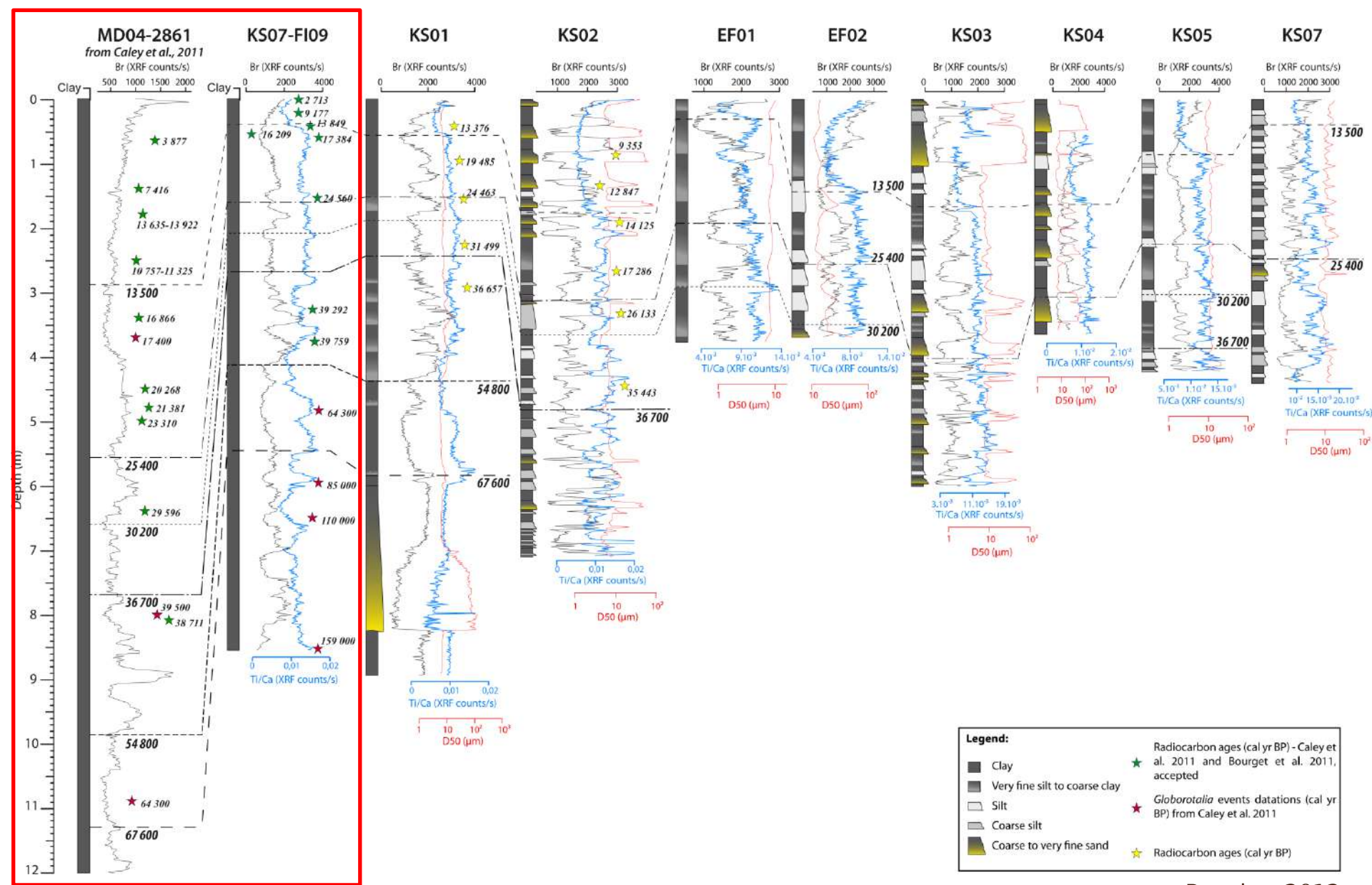




Baurion 2012

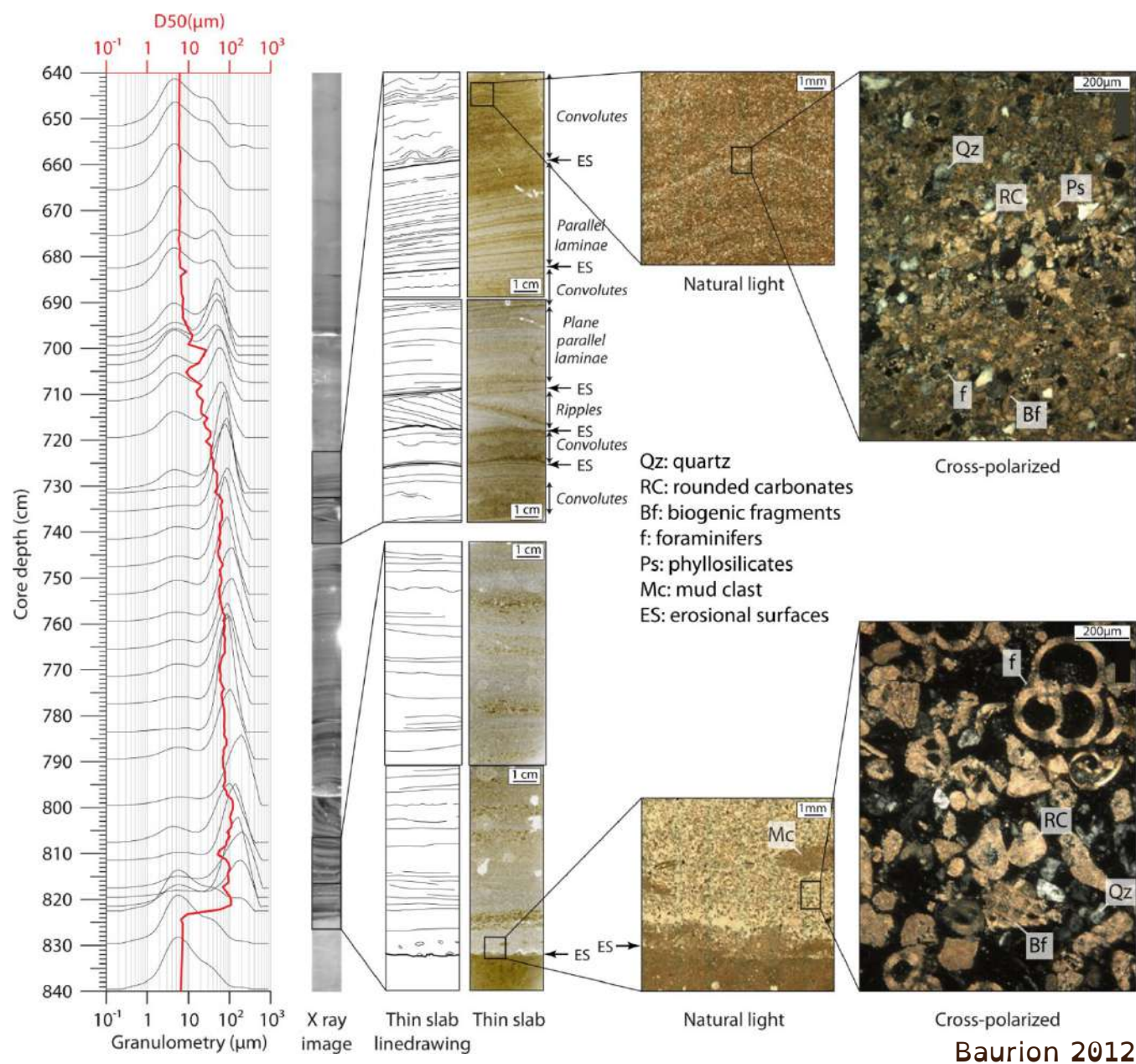






Baurion 2012



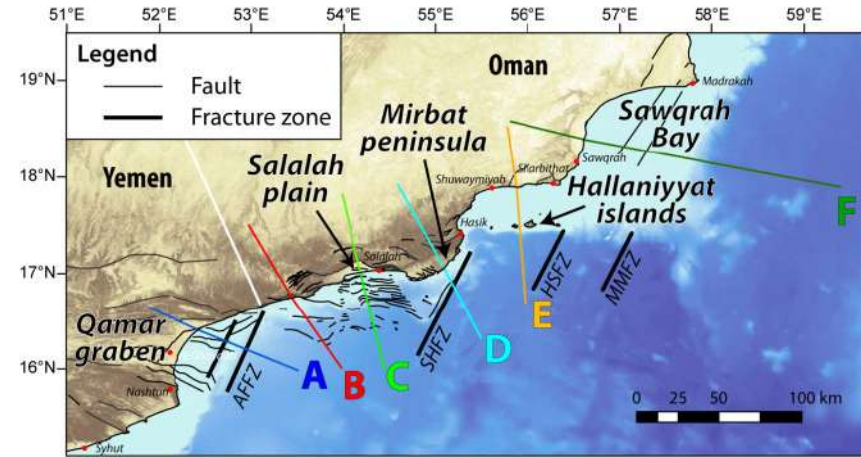
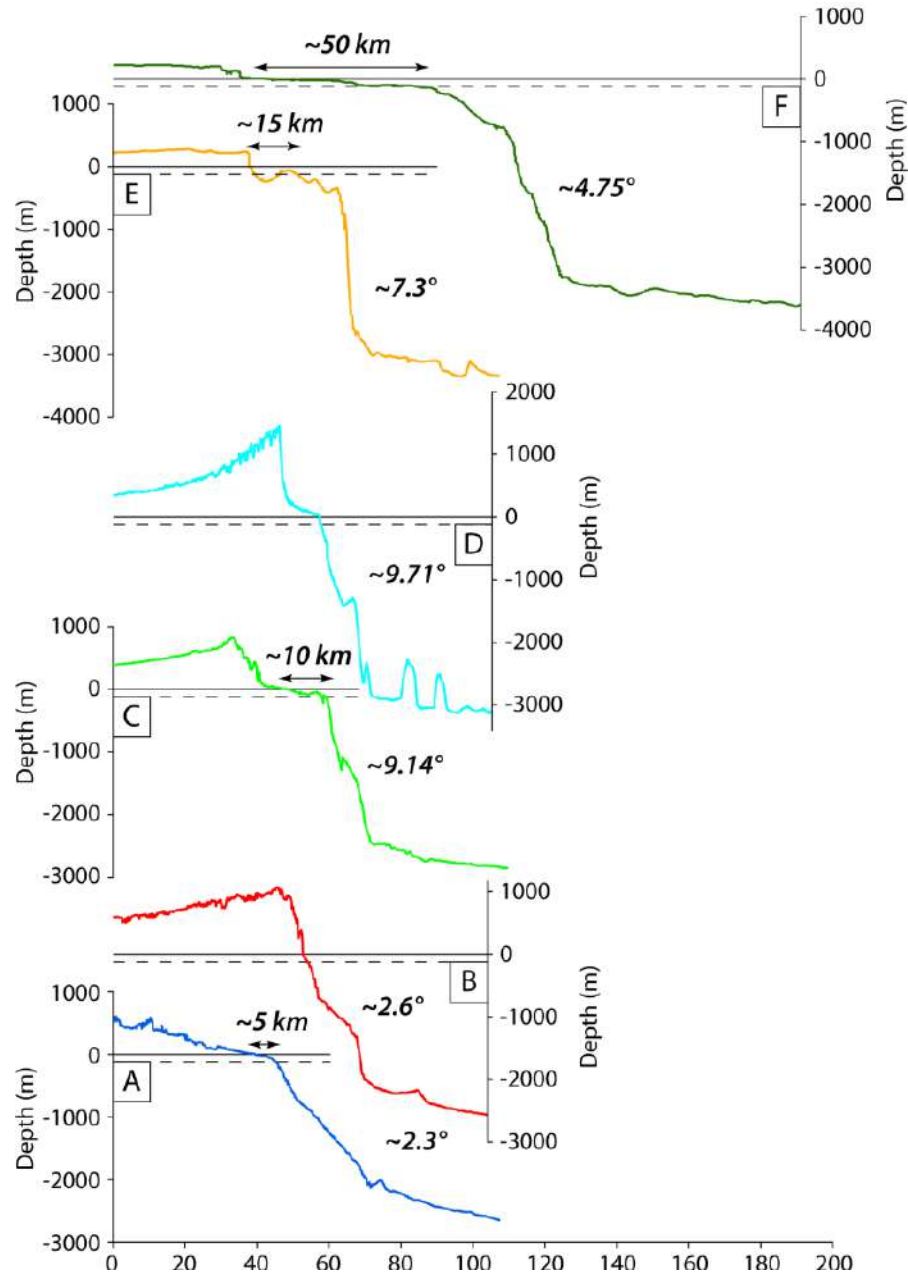


Baurion 2012

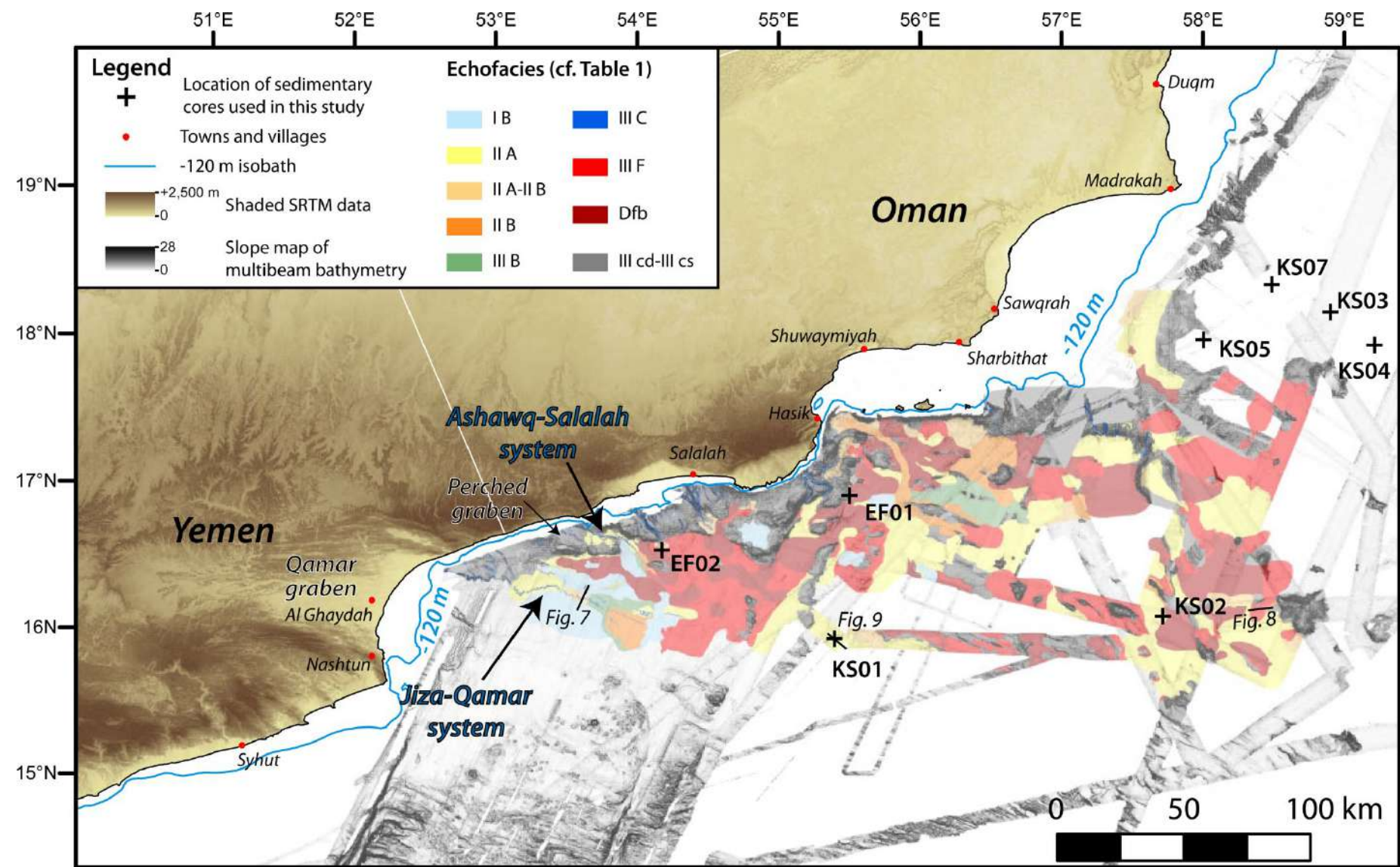




# Le golfe d'Aden



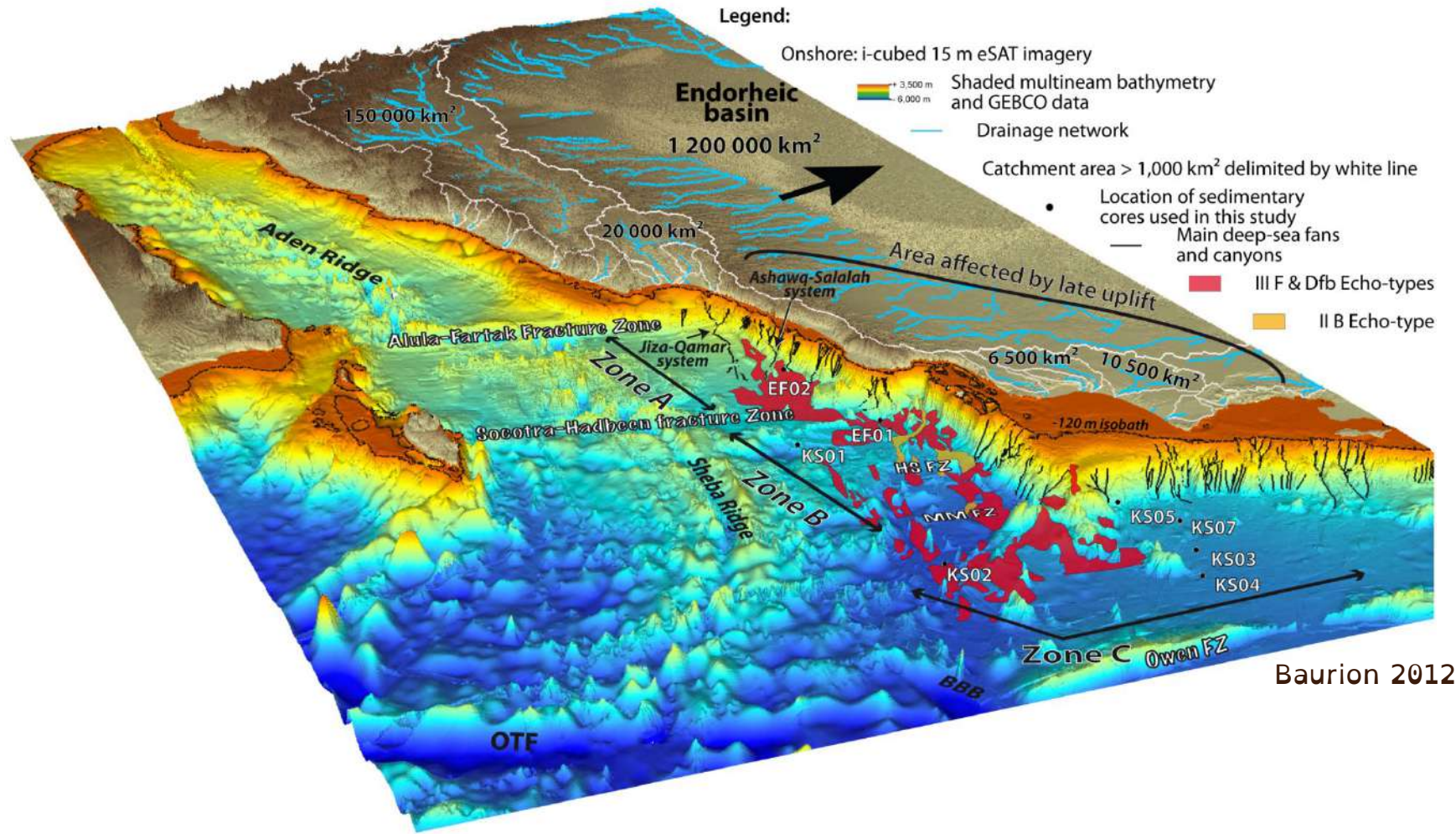
Baurion 2012



Baurion 2012



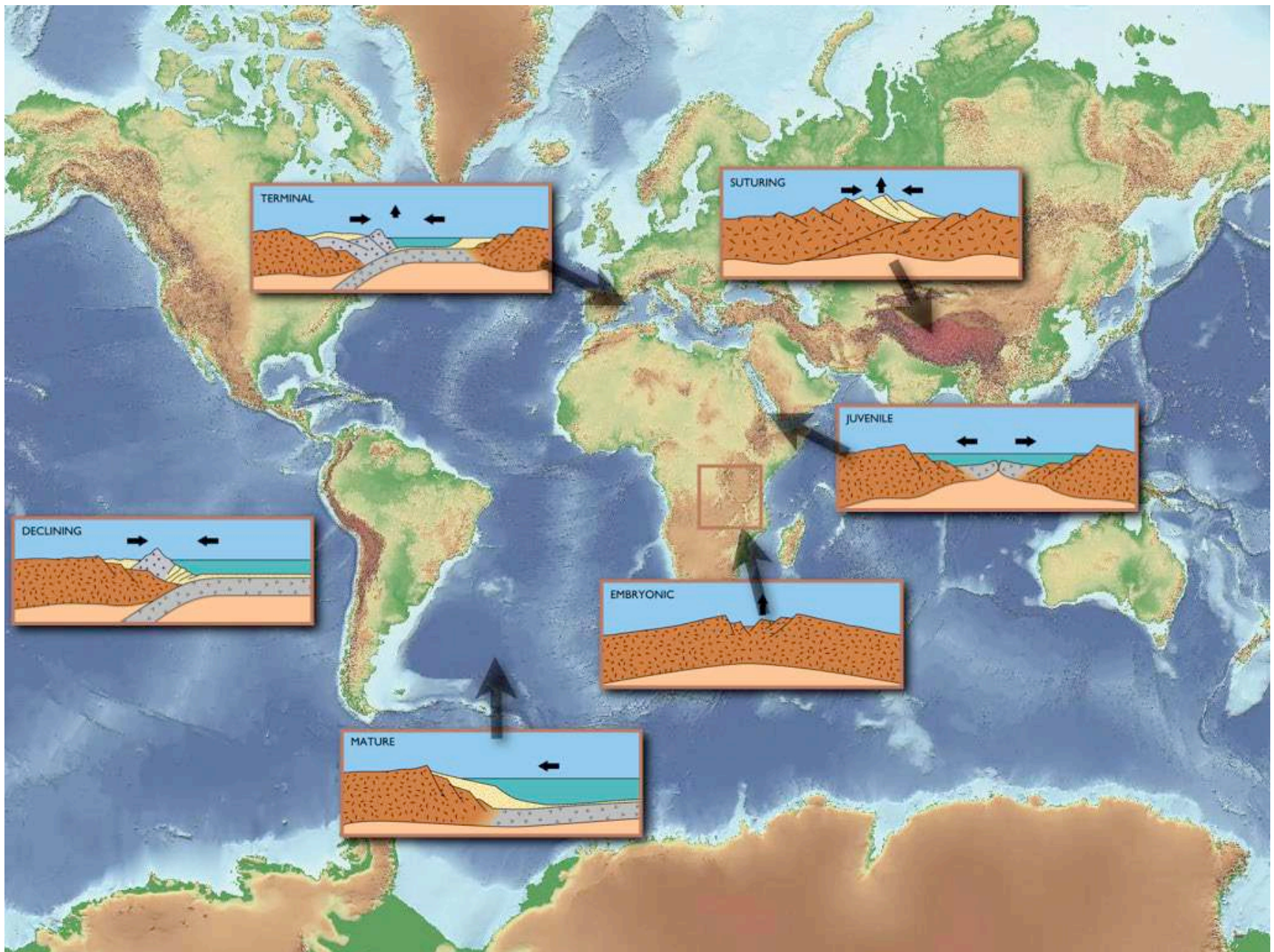




Baurion 2012



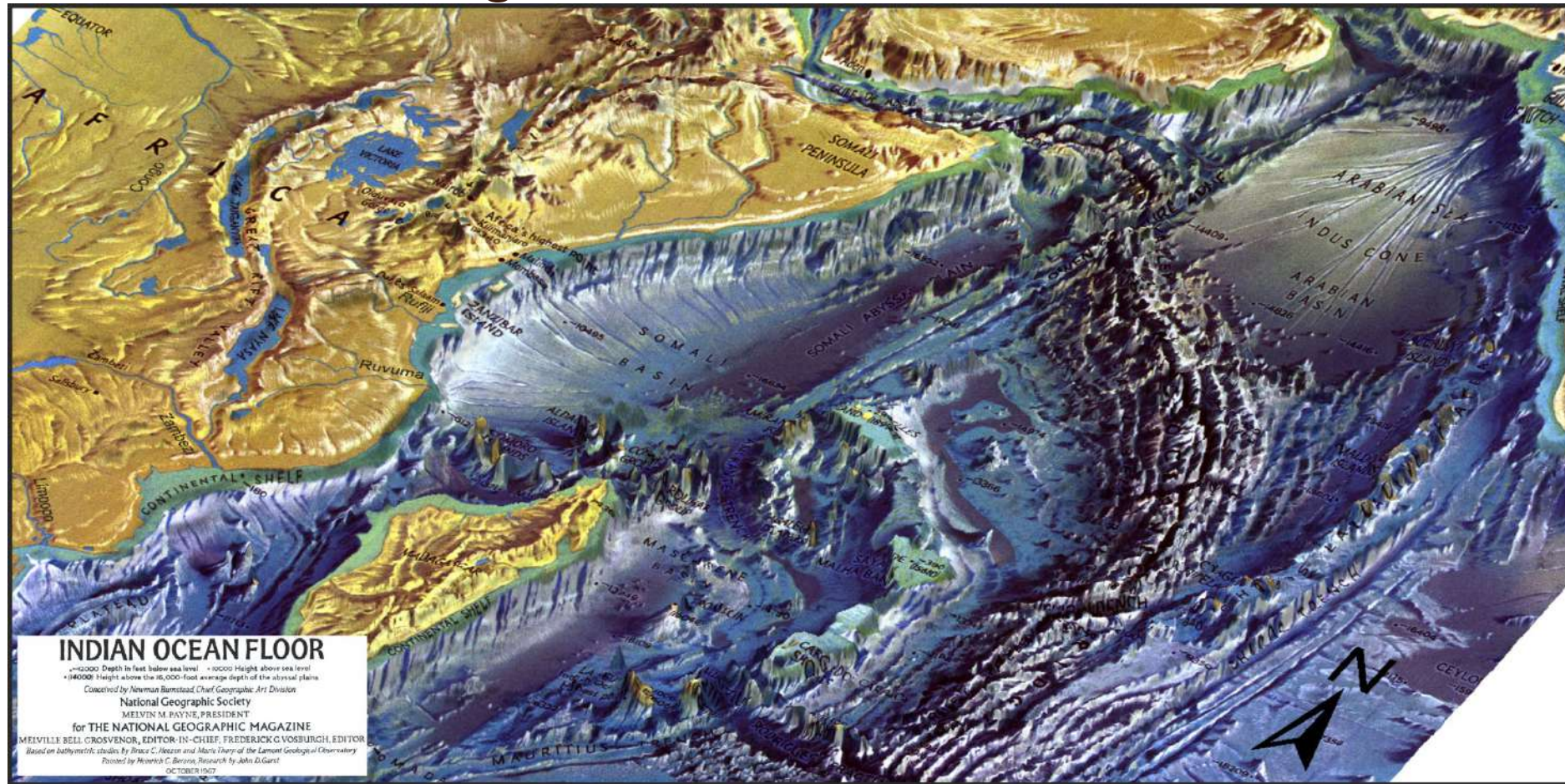




[http://commons.wikimedia.org/wiki/File:Wilson-stages\\_hg.png](http://commons.wikimedia.org/wiki/File:Wilson-stages_hg.png)



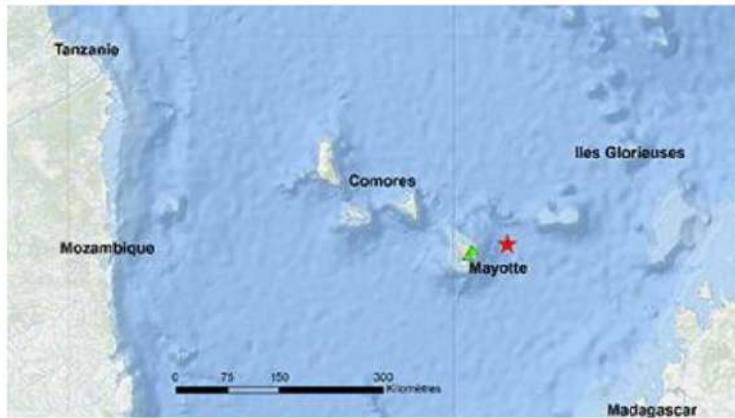
# La marge tanzanienne et les Comores





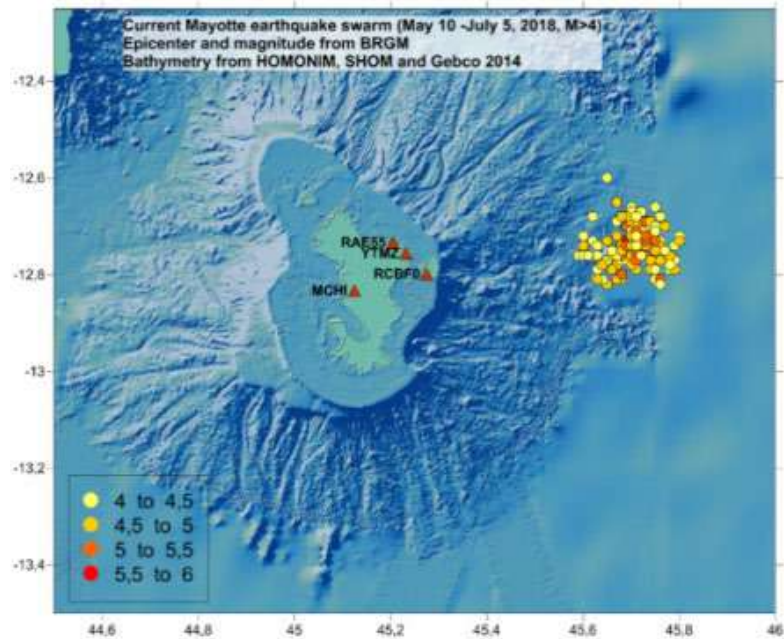
# Séismes à Mayotte : jusqu'à quand cela peut-il durer ?

Depuis le 10 mai, Mayotte connaît une activité sismique soutenue, causant de nombreux dégâts. Plusieurs centaines de secousses ont été enregistrées dont une de magnitude de 5,8, la plus forte jamais ressentie sur l'île. Jusqu'à quand cela va-t-il durer ?

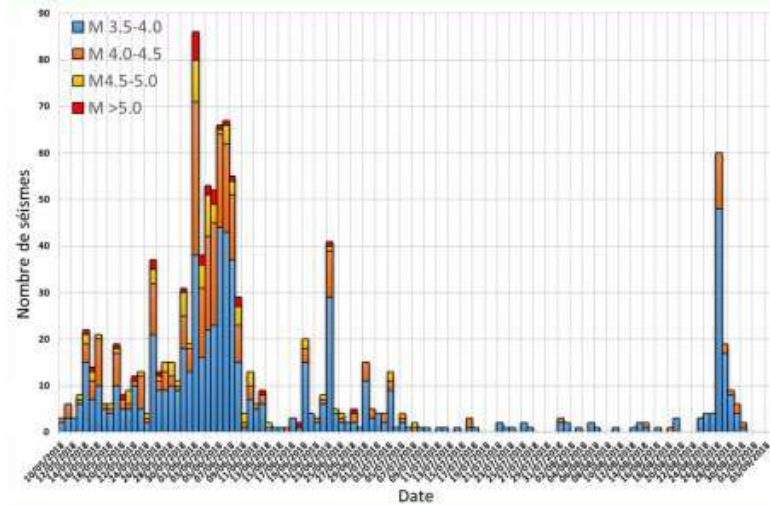


© BRGM Localisation de l'épicentre (étoile rouge) de la crise sismique de Mayotte (mai 2018)

Par Cécile Baquey  
Publié le 29/05/2018 à 12:23, mis à jour le 29/05/2018 à 13:17

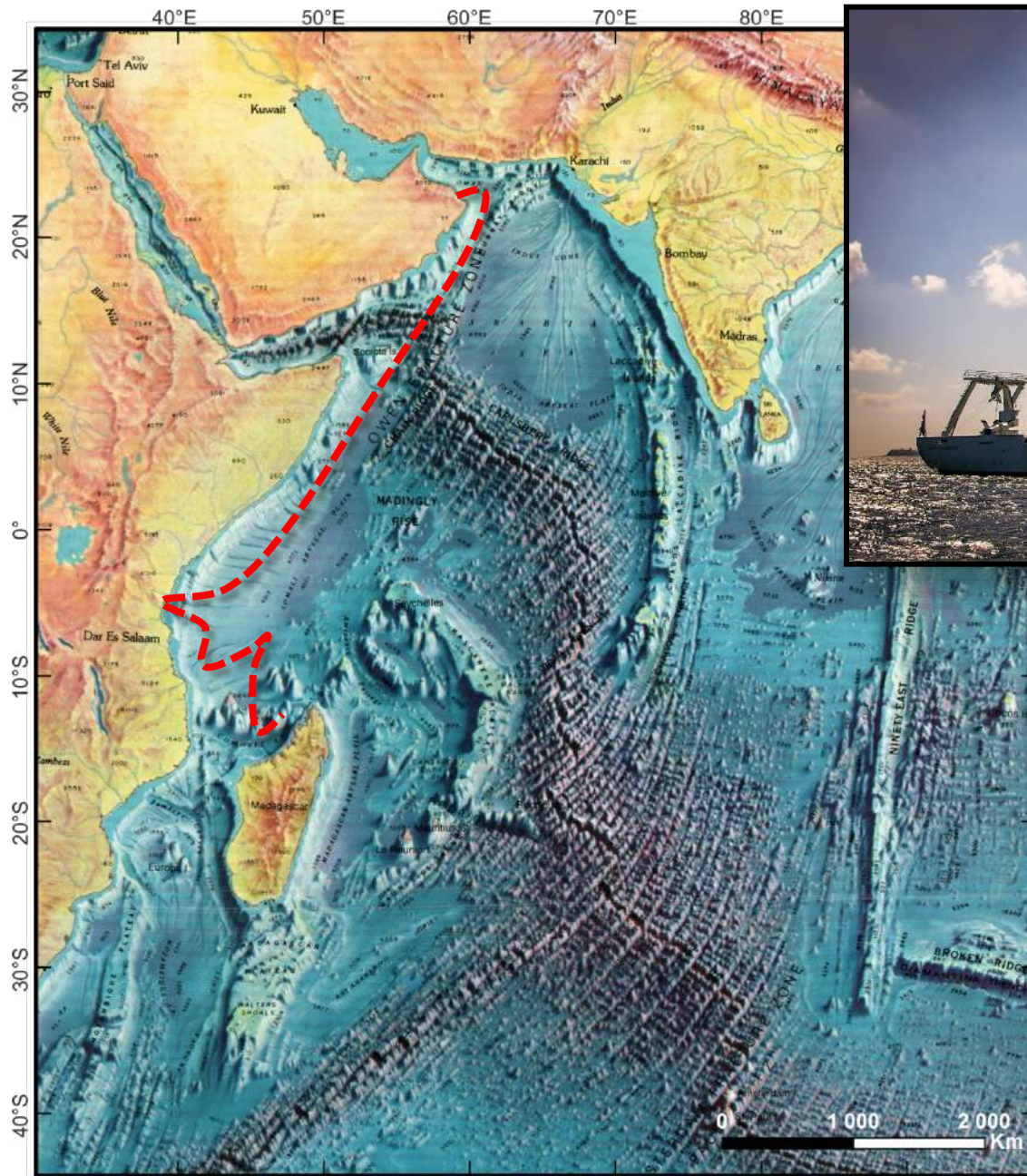


Carte de localisation des principaux séismes de l'essaim sismique en cours à Mayotte  
Source : BRGM?



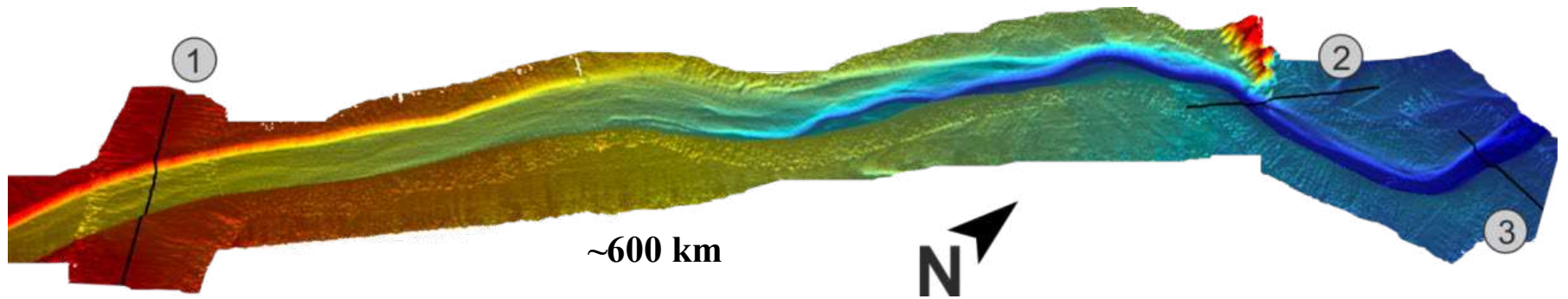
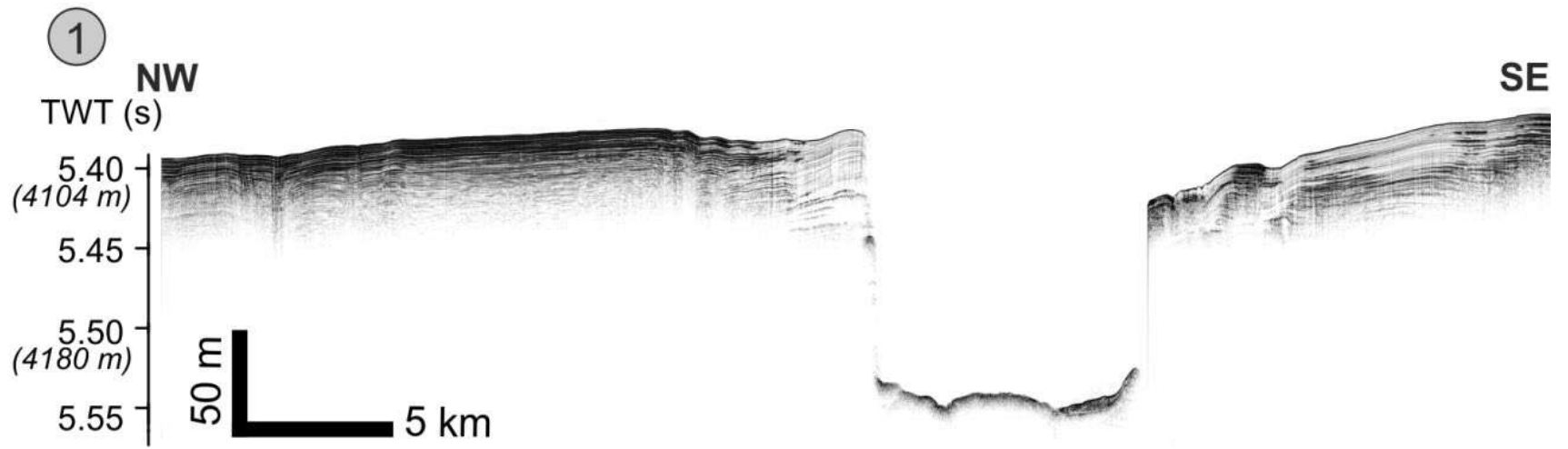
Nombre journalier de séismes en fonction de leur magnitude  
Source : BRGM?



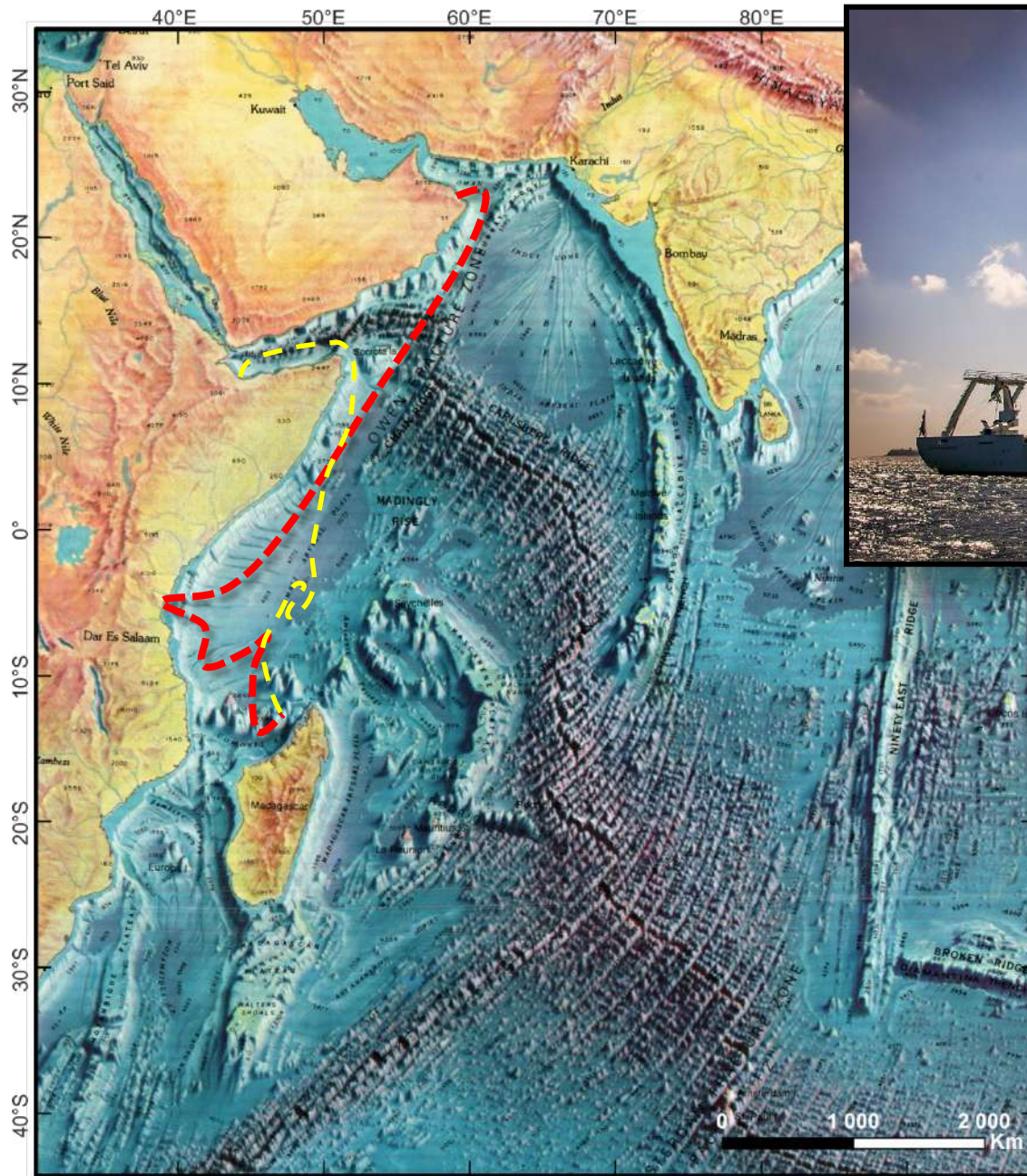


Océanographie Indienne 2006

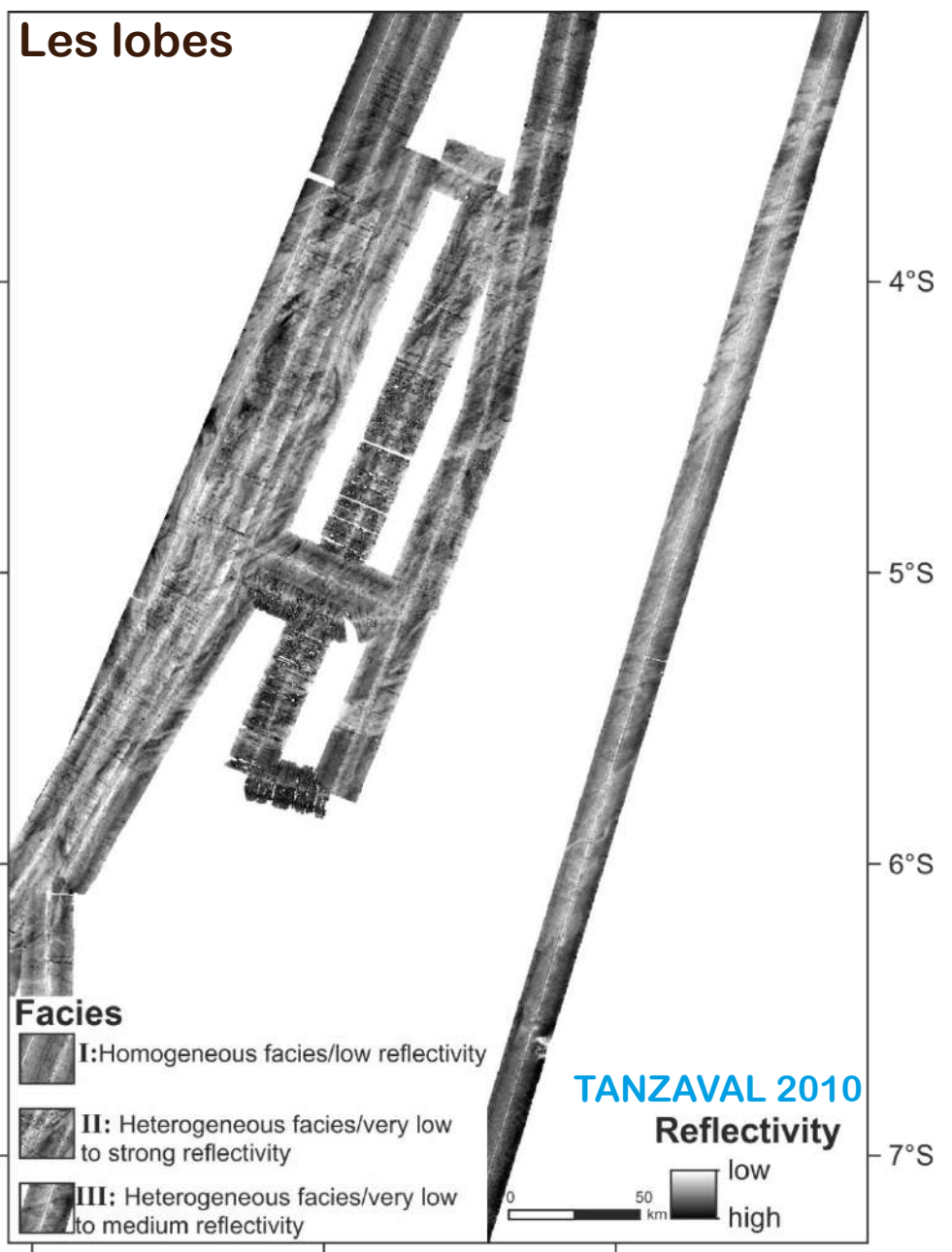
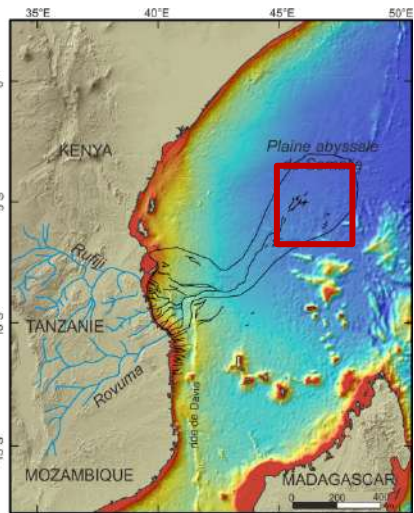




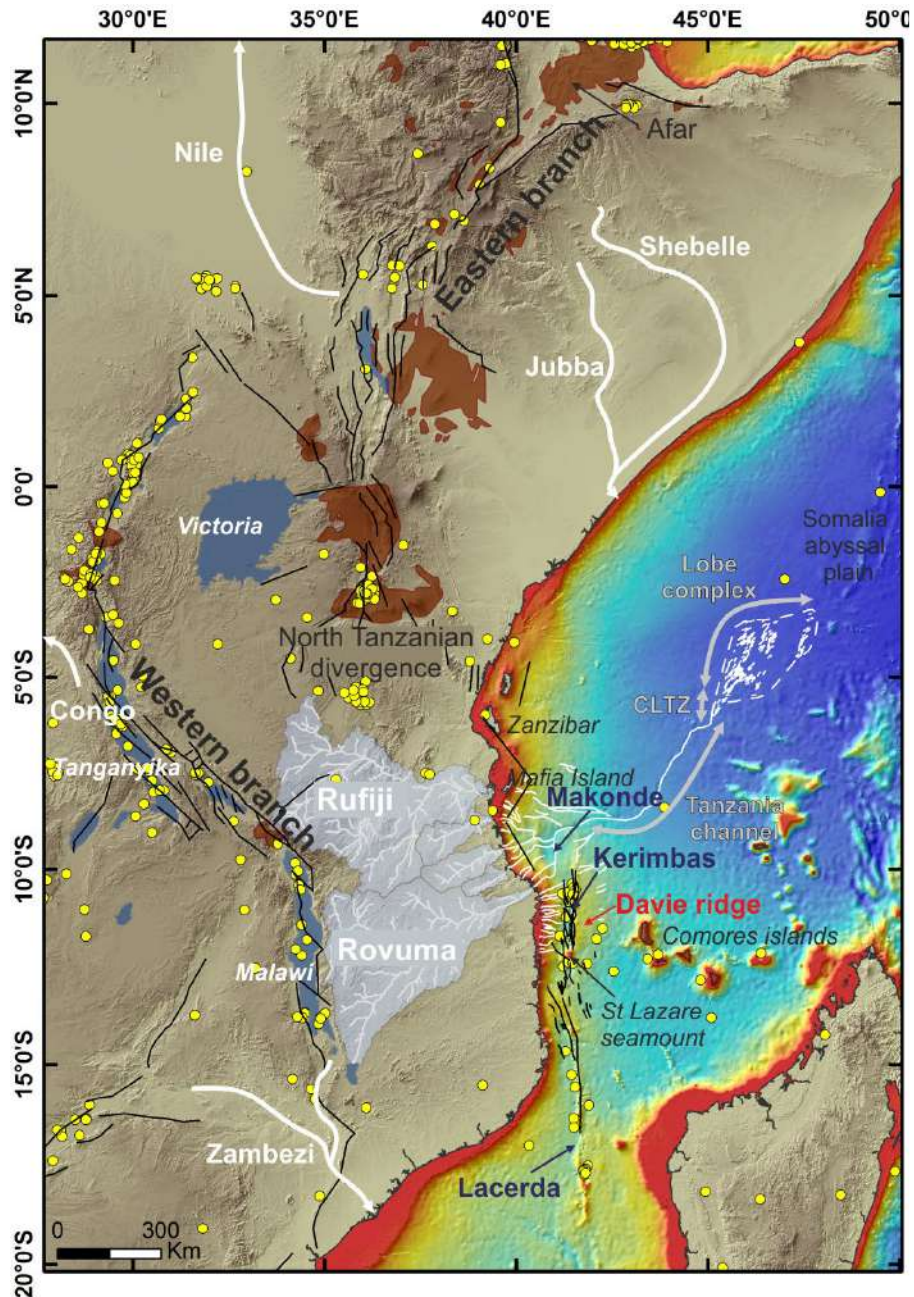




TANZANAI 2010







**Legend:**

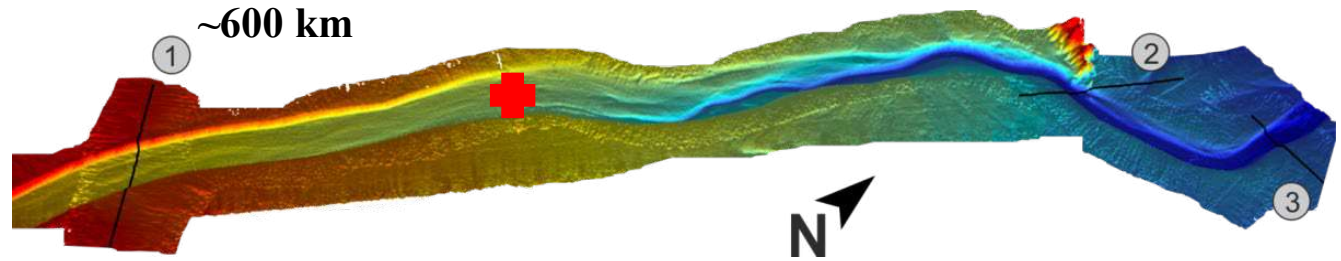
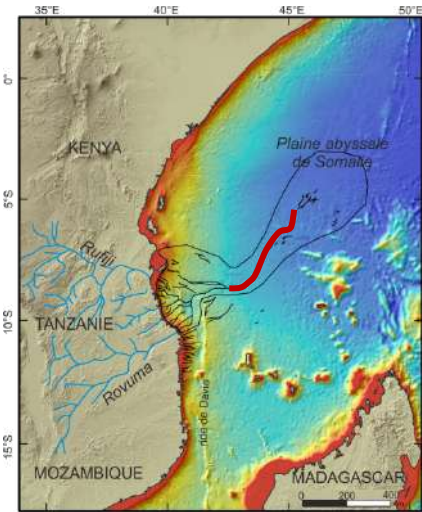
- Faults (Chorowicz, 2005, Franke et al., 2015)
- EHB Catalogue Seismicity
- Volcanism (MacGregor, 2015)

**Topography:**  
 5090 m  
 -150 m

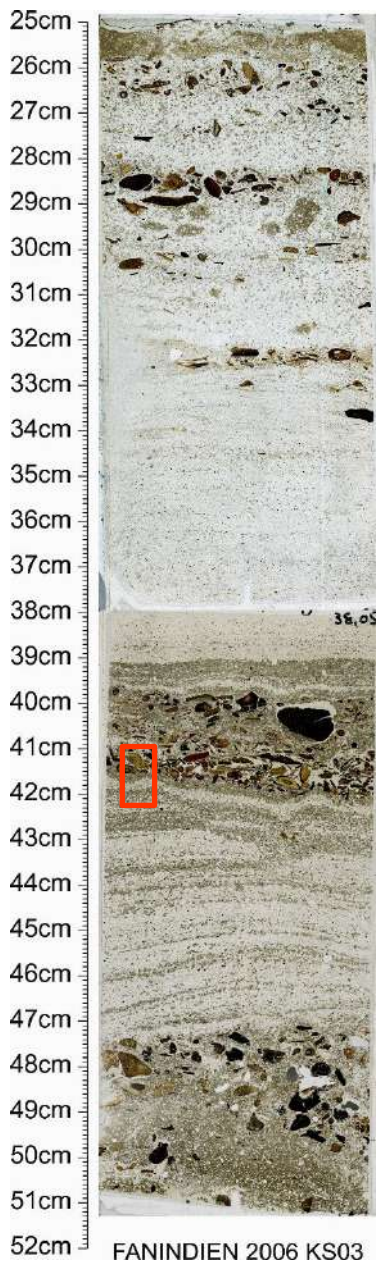
**Bathymetry:**  
 25 m  
 -5385 m



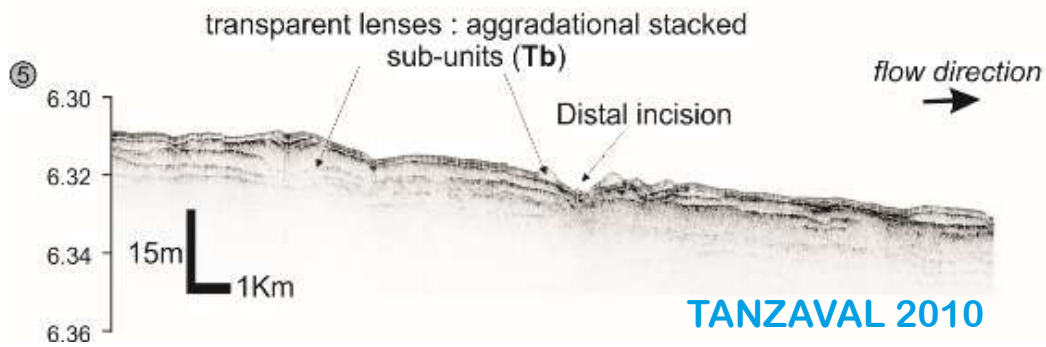
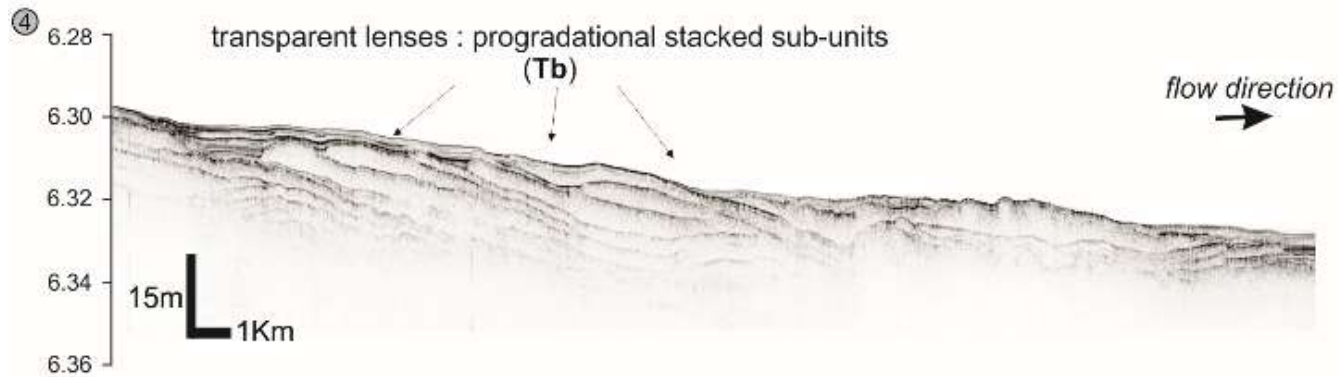
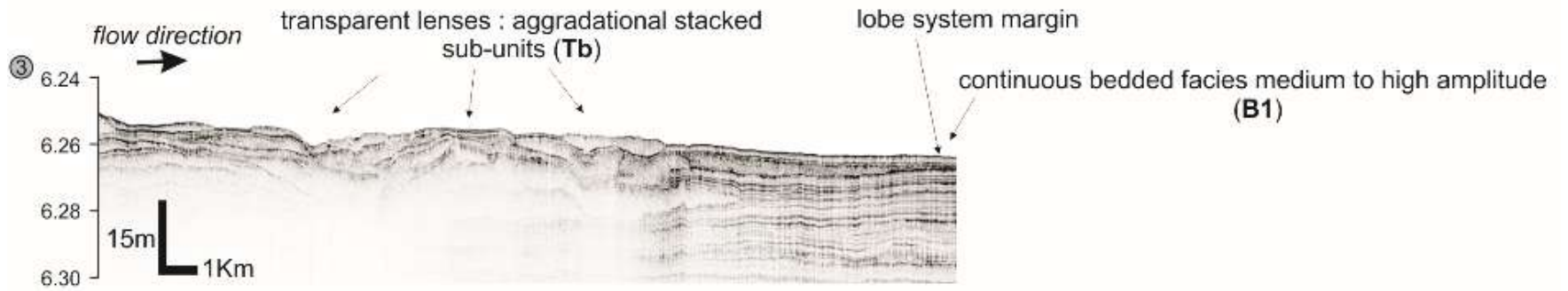
# Le chenal de Tanzanie



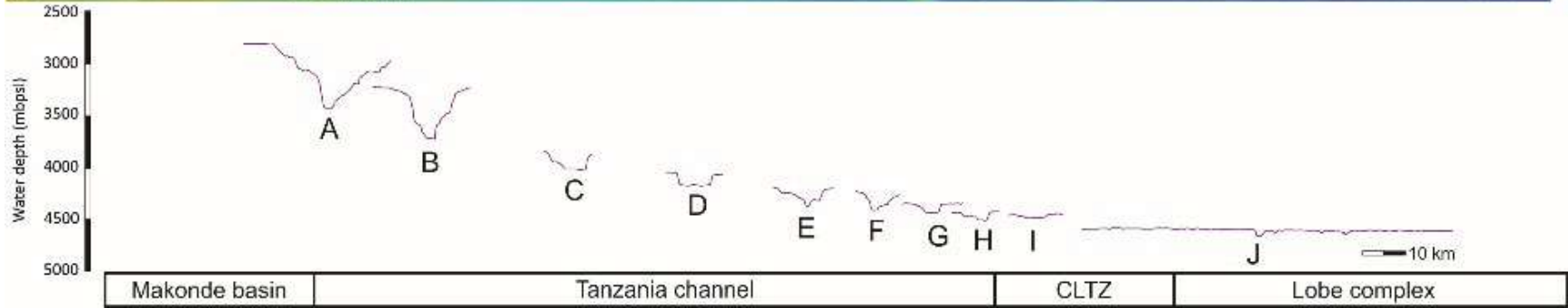
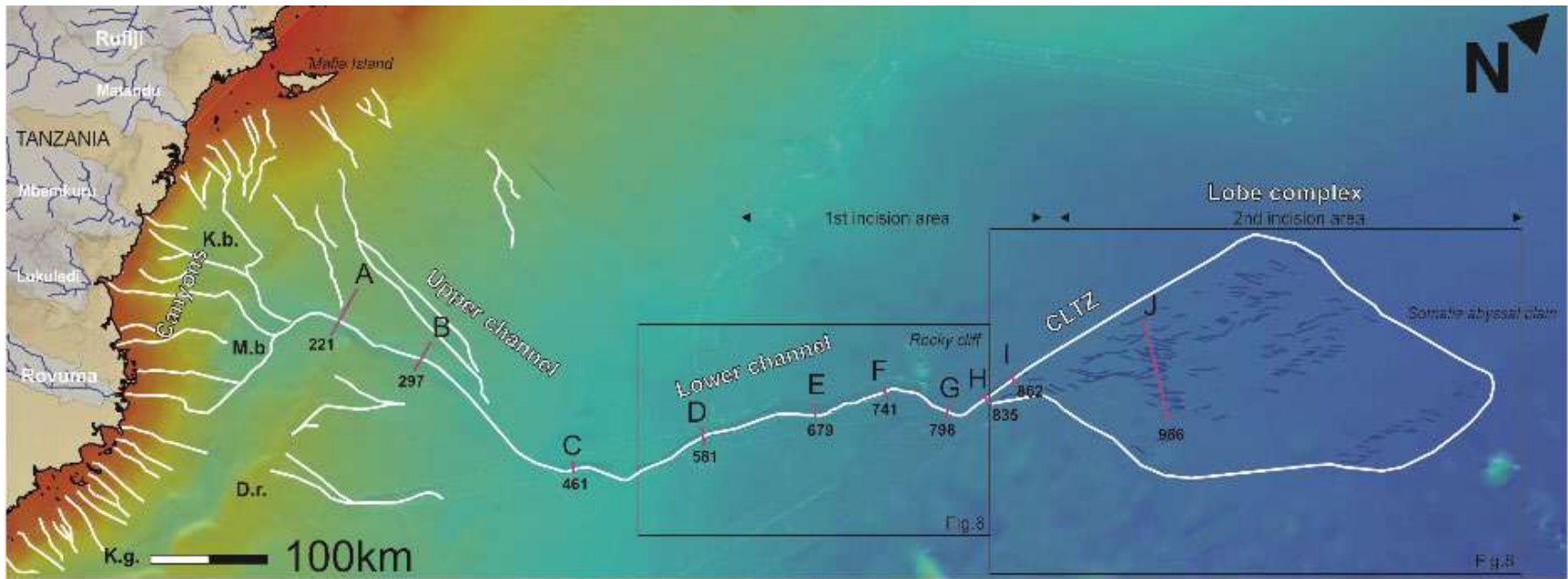


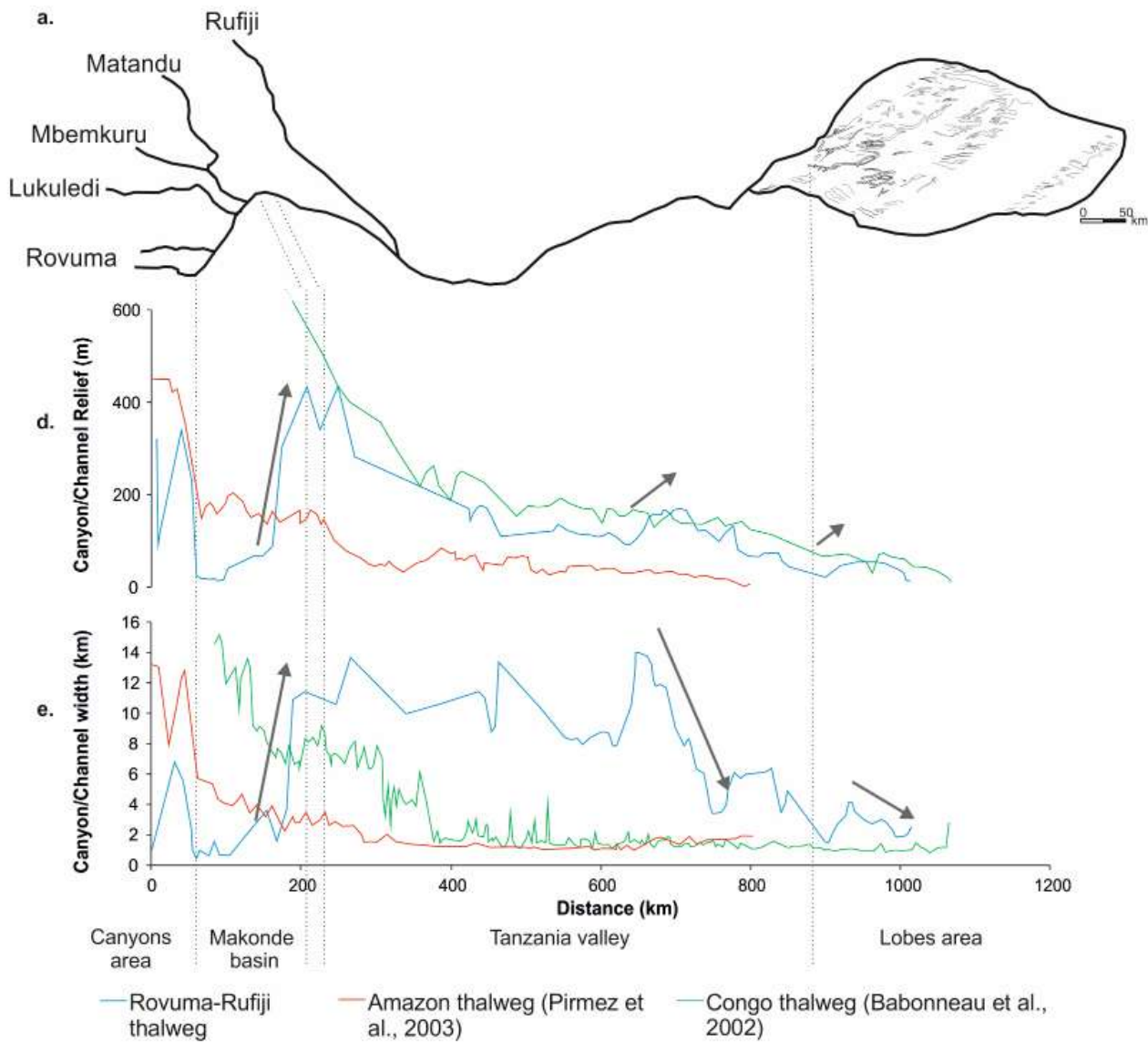


1 cm

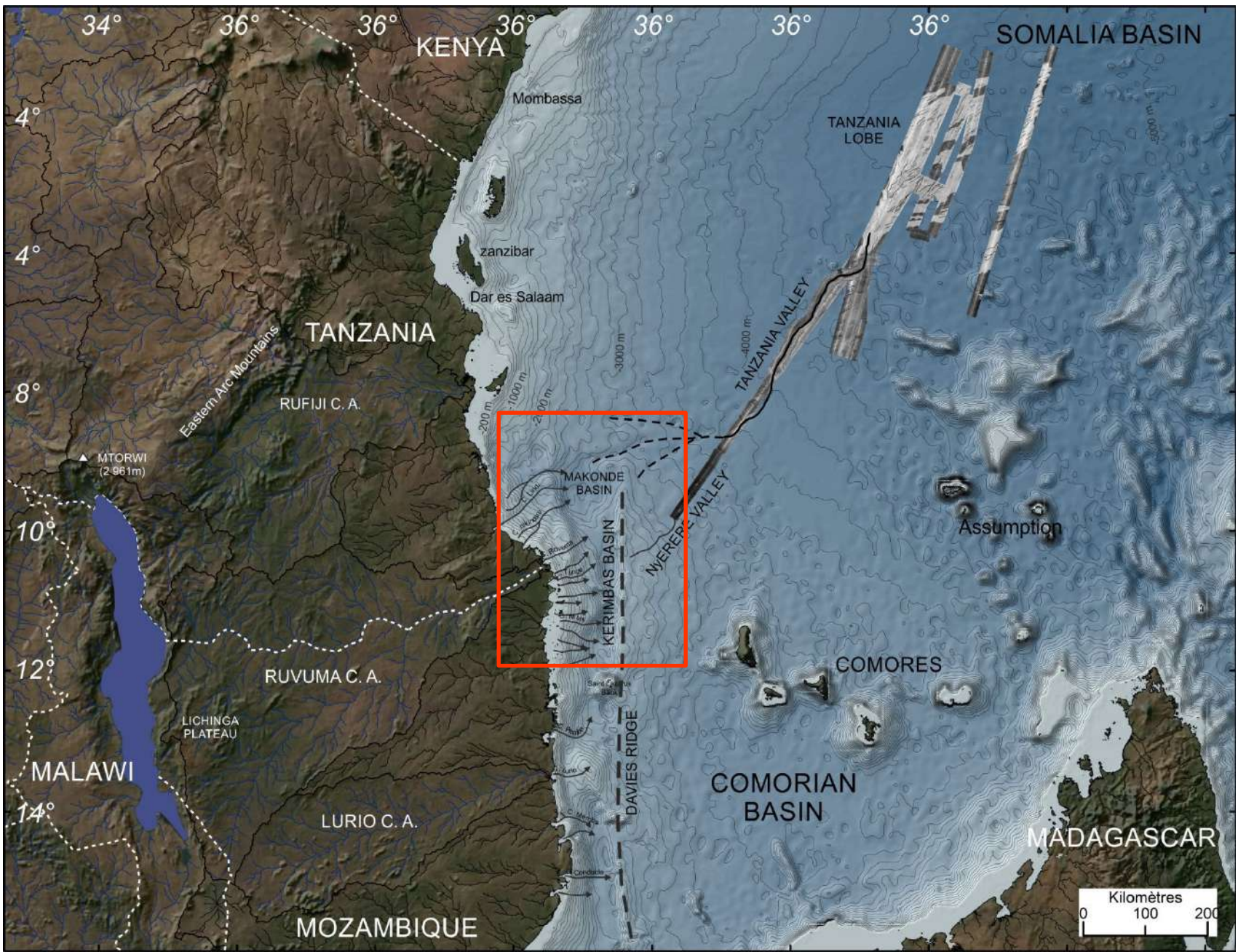




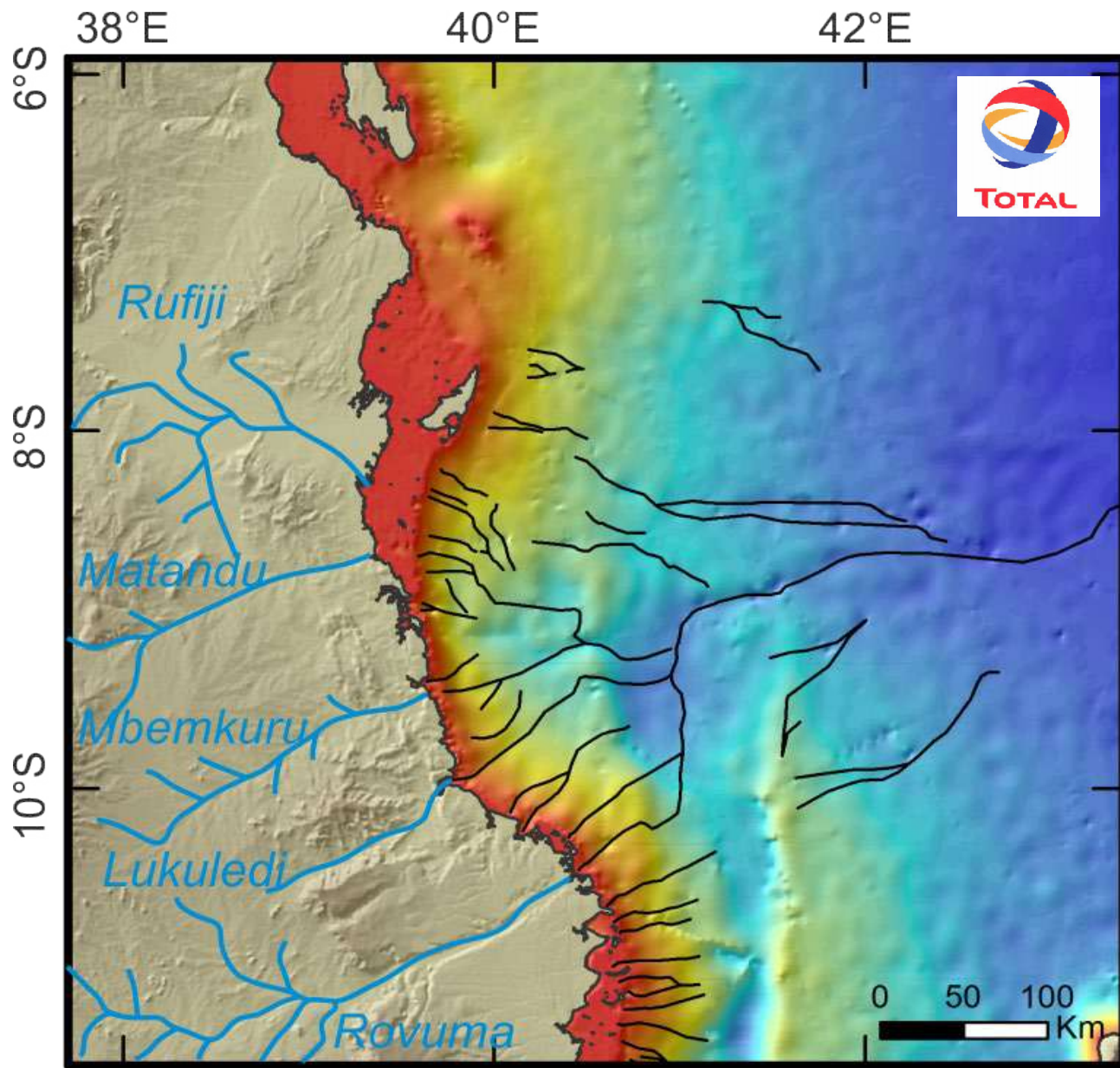




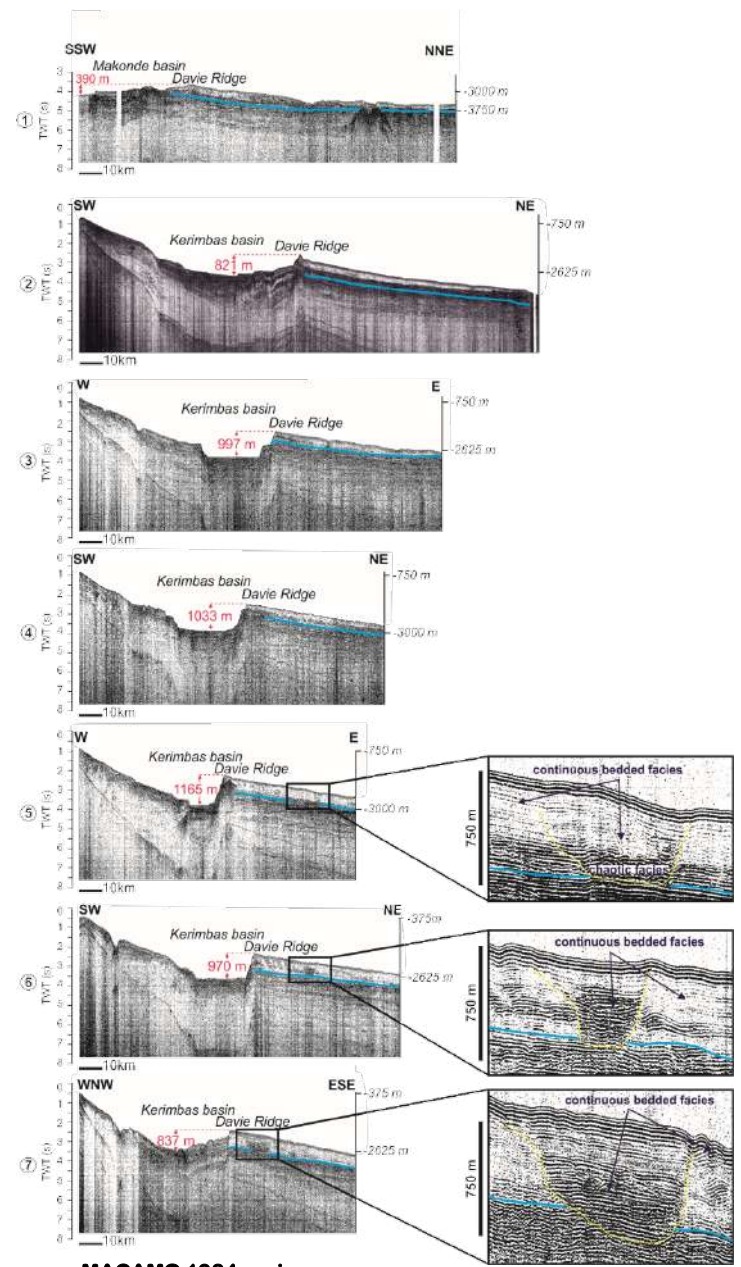
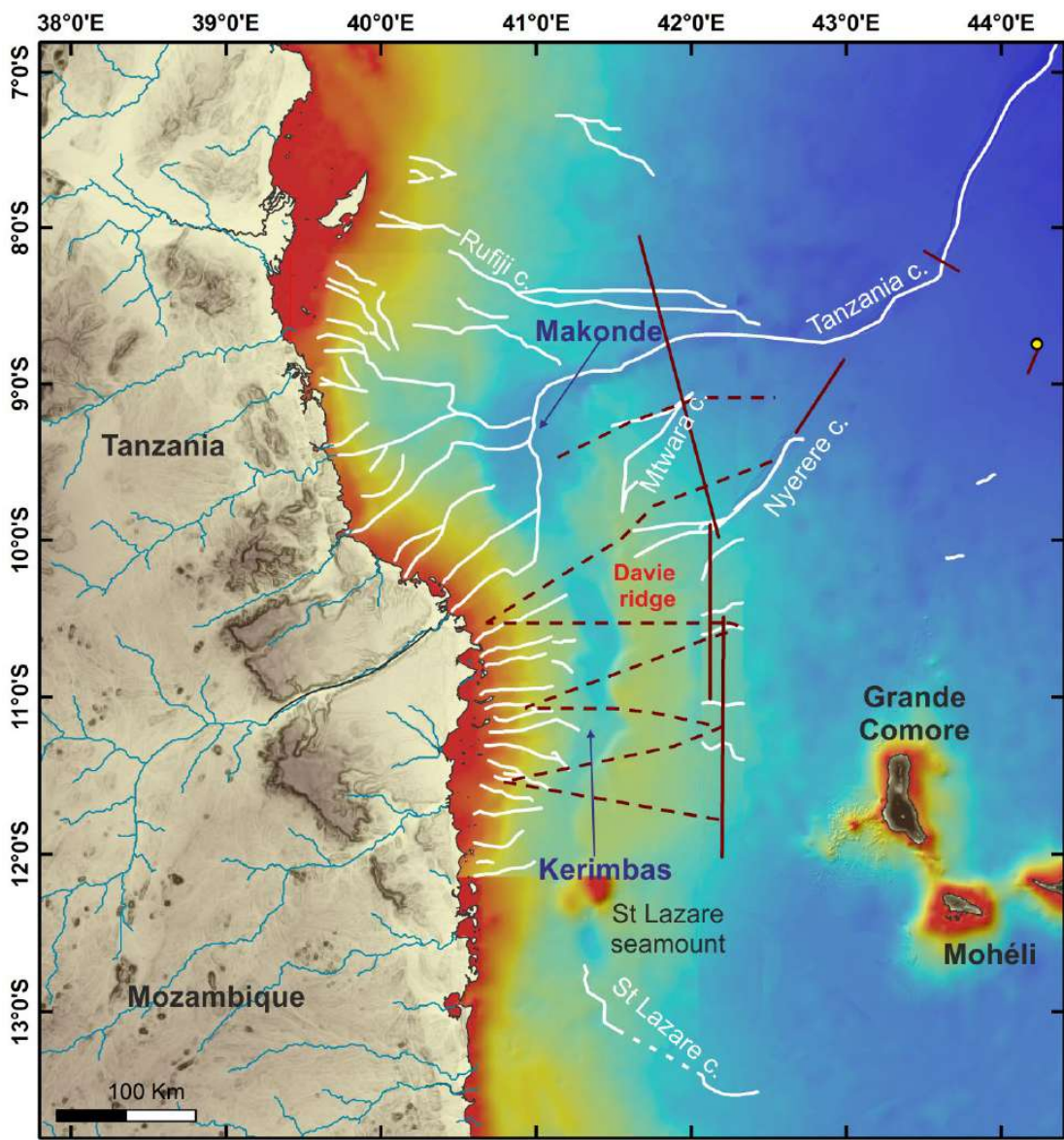








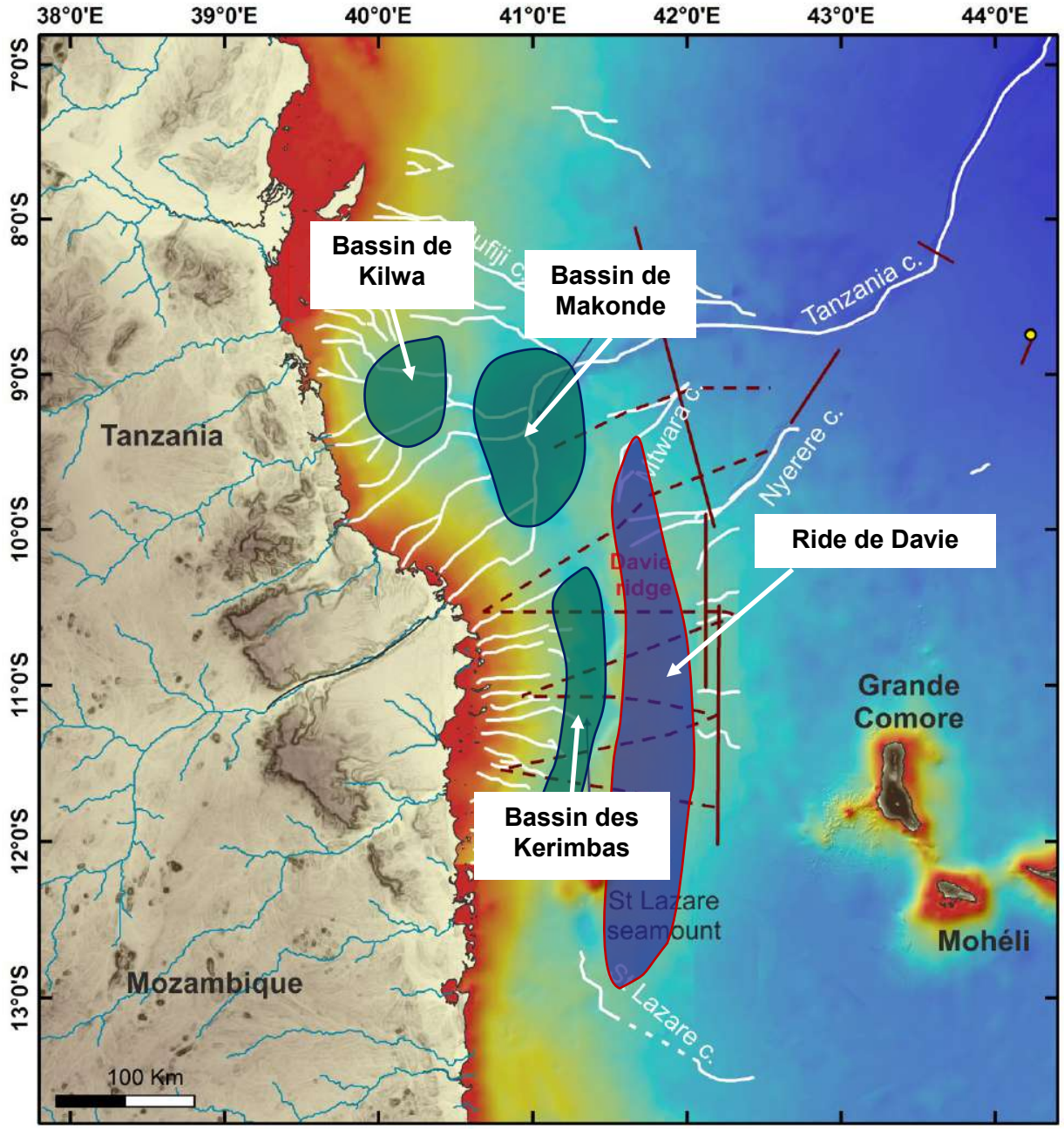




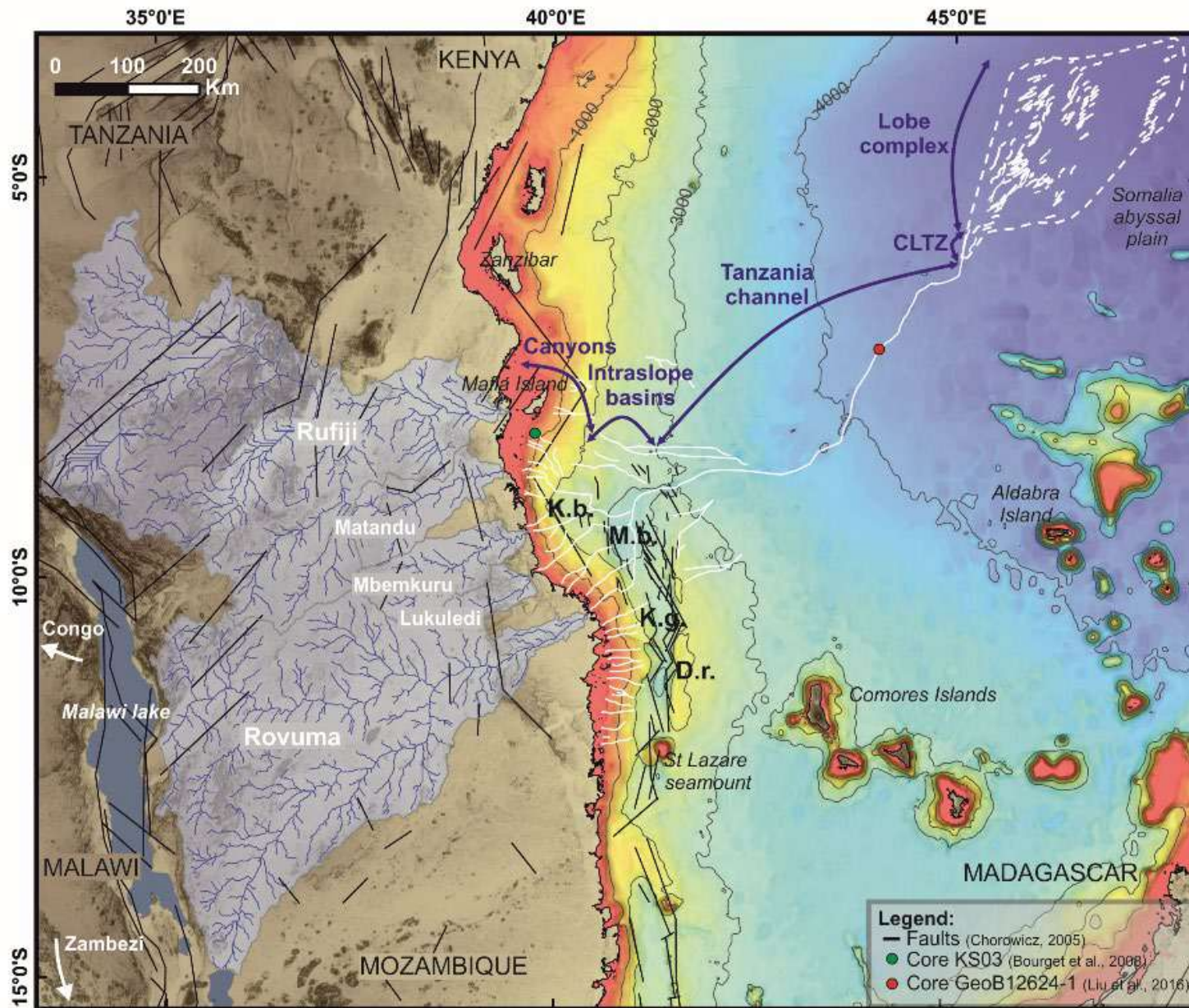
**MACAMO 1984 cruise**

Mougenot, D., M. Recq, P. Virlogeux, et C. Lepvrier. 1986  
 « SEAWARD EXTENSION OF THE EAST-AFRICAN RIFT »,  
*Nature* 321, n° 6070: 599-603.

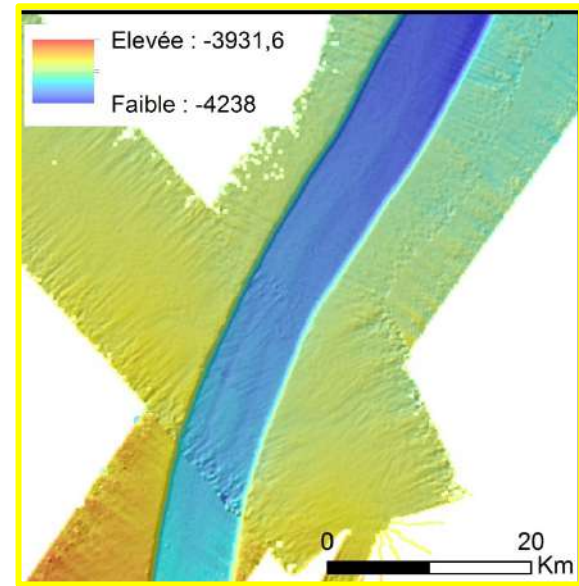
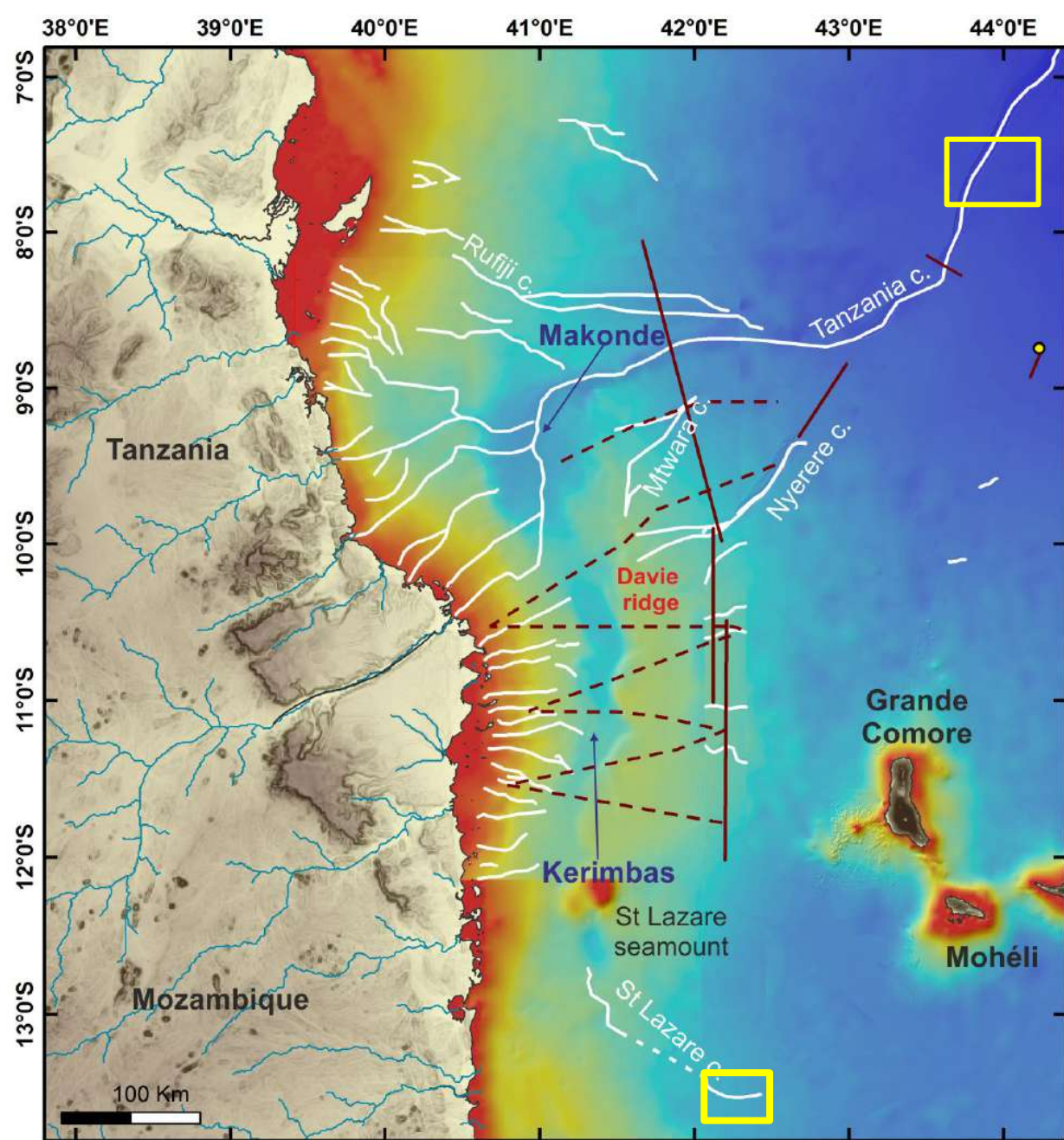




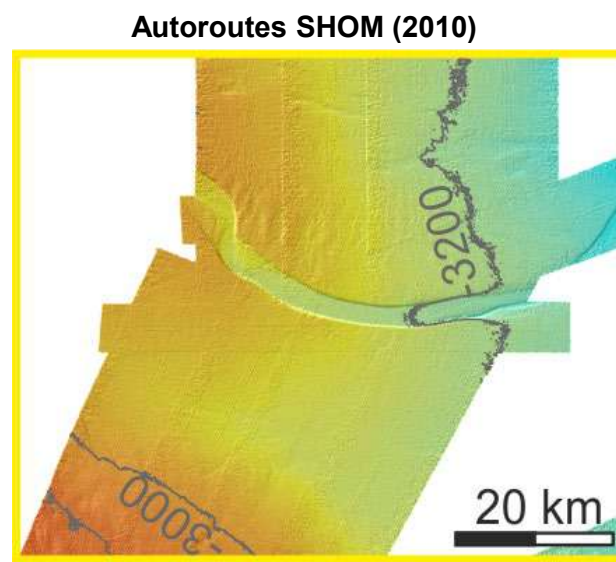








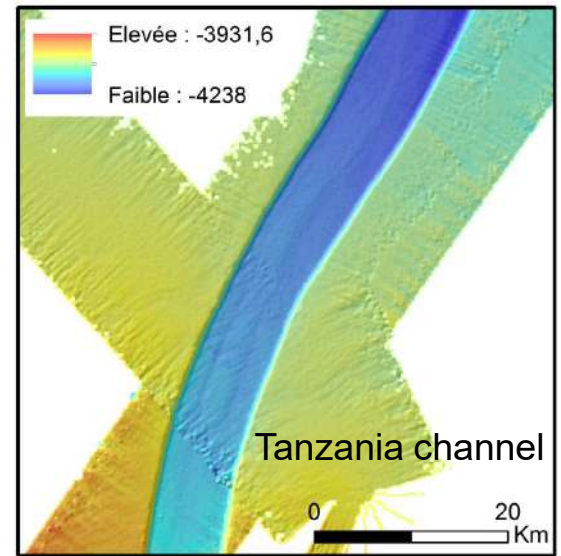
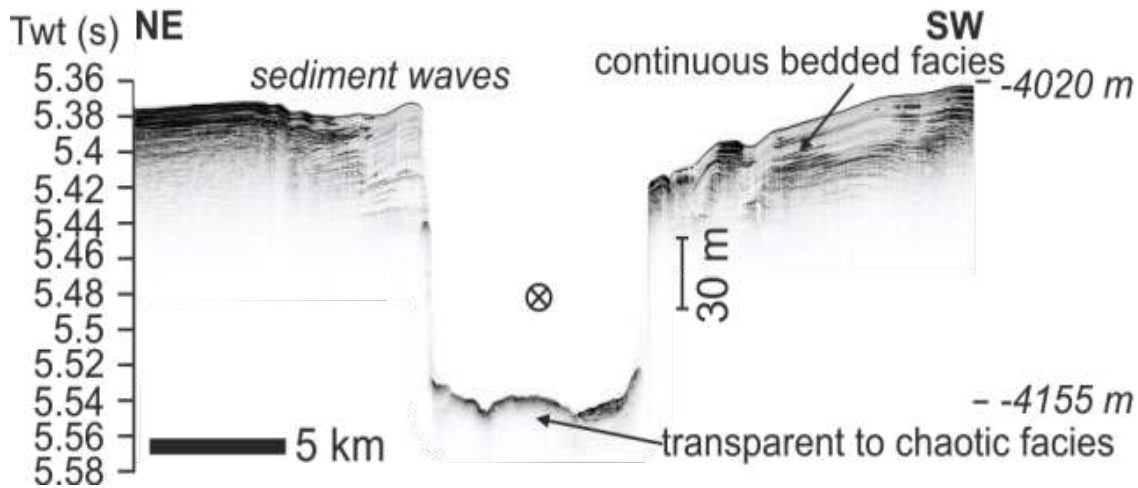
FanIndien (2006)



Autoroutes SHOM (2010)

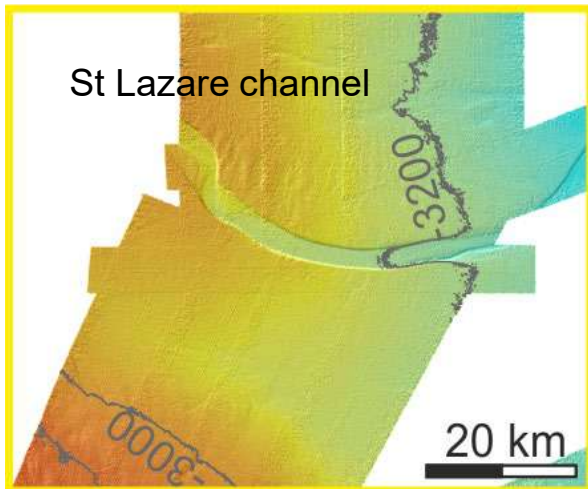


### Tanzania channel

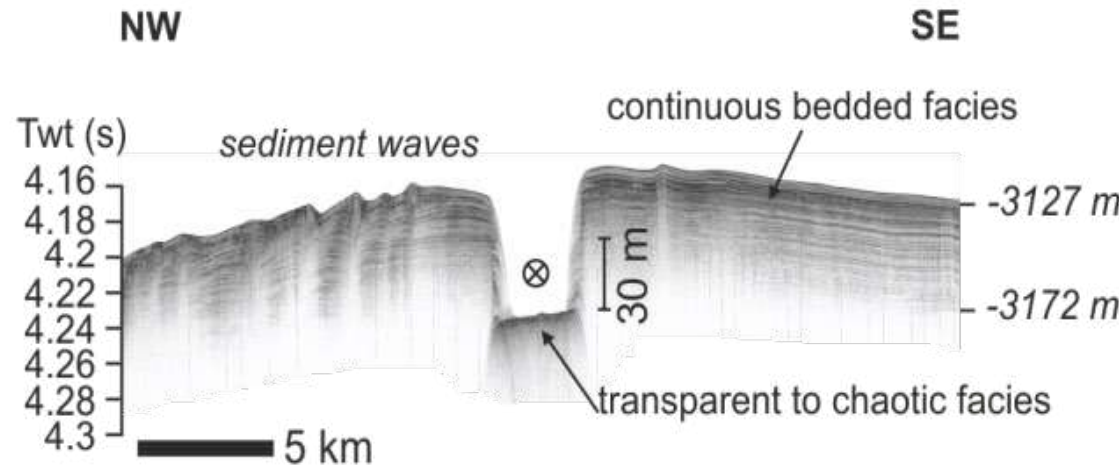


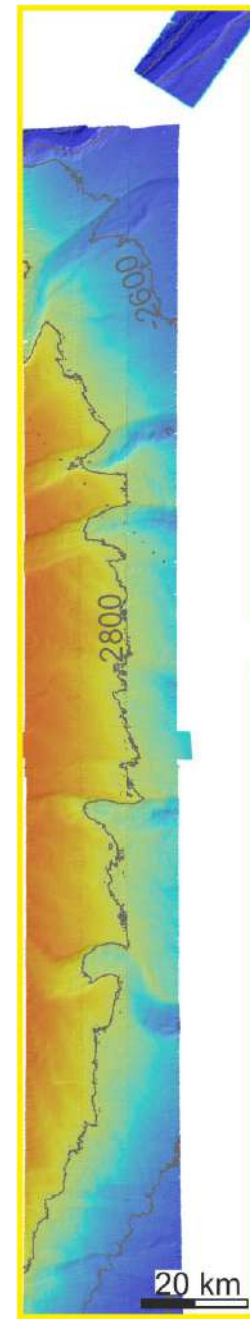
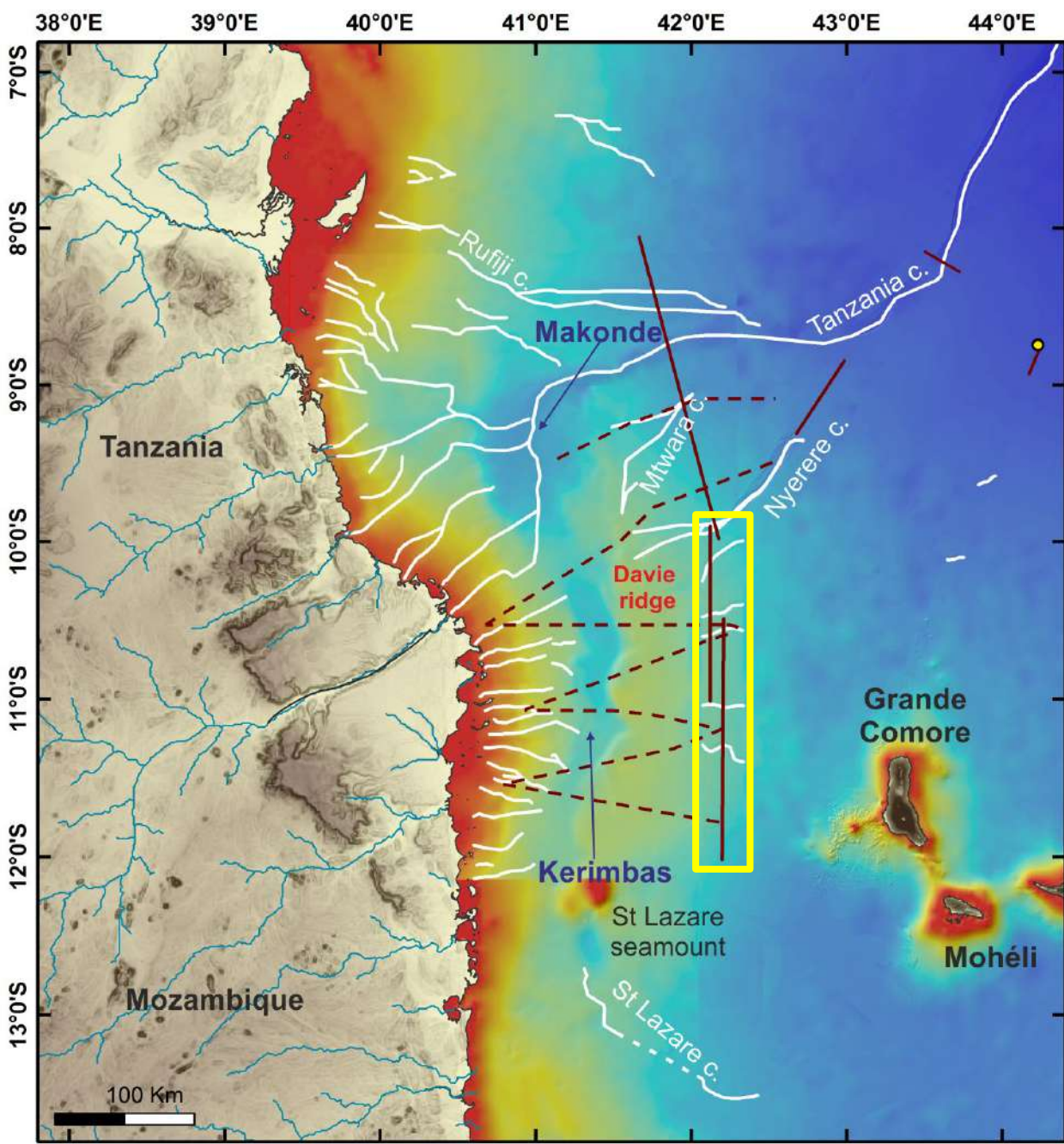
FanIndien (2006)

### Autoroutes SHOM (2010)



### St Lazare channel



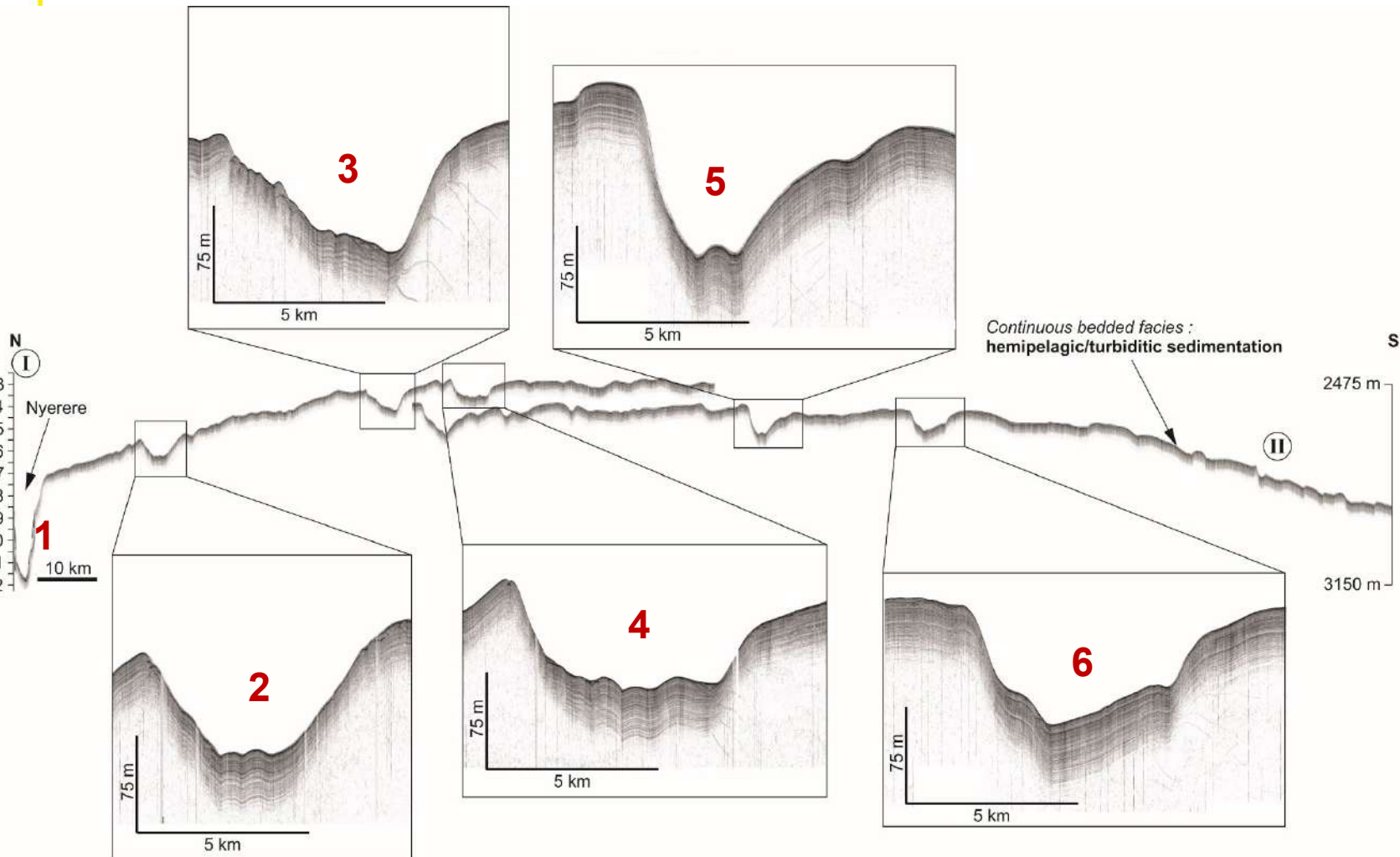
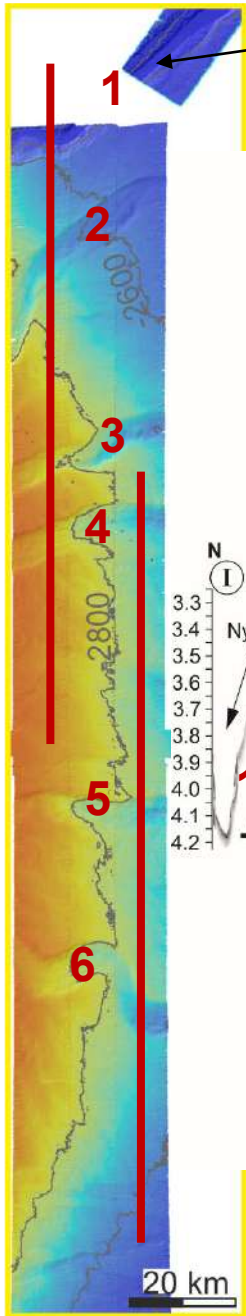


Autoroutes SHOM (2010)

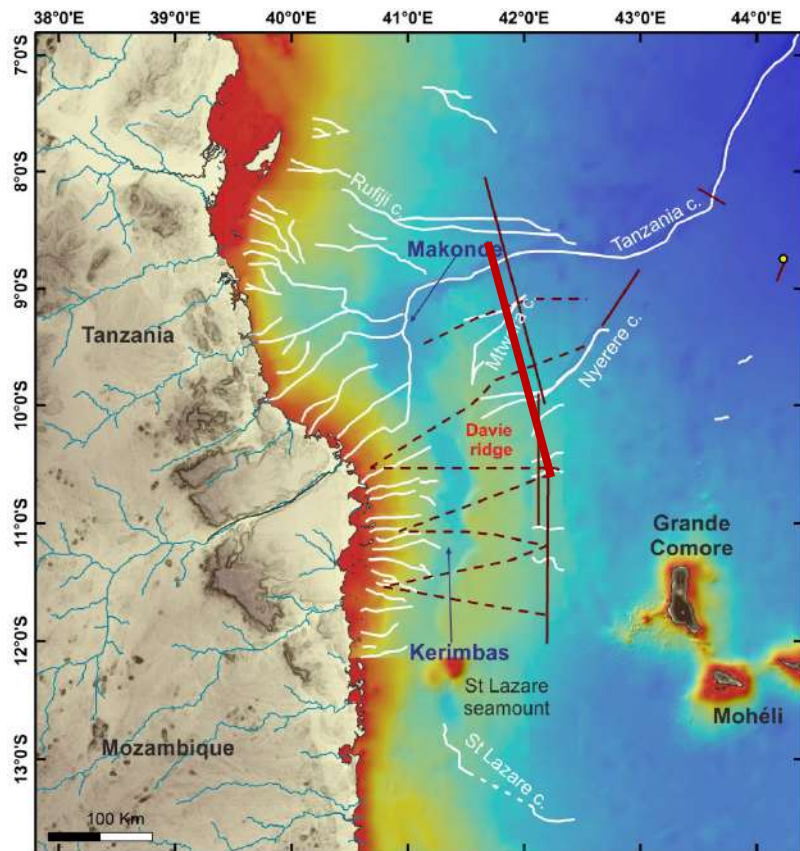
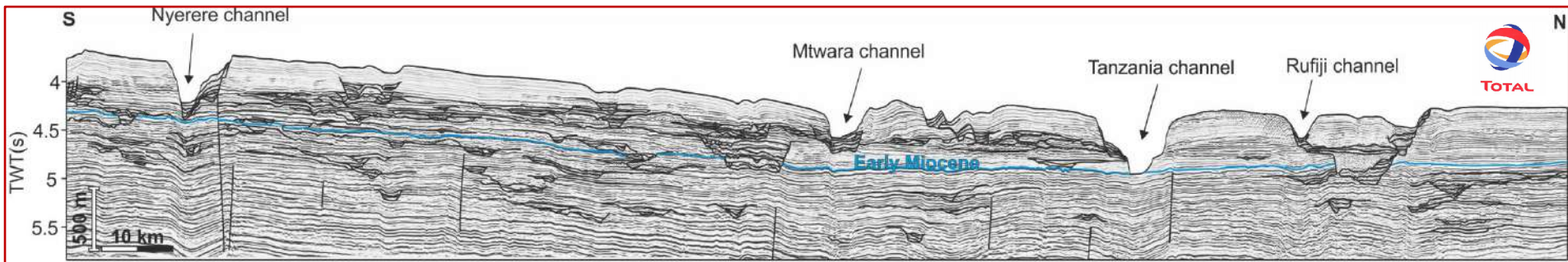




Chenal de Nyerere



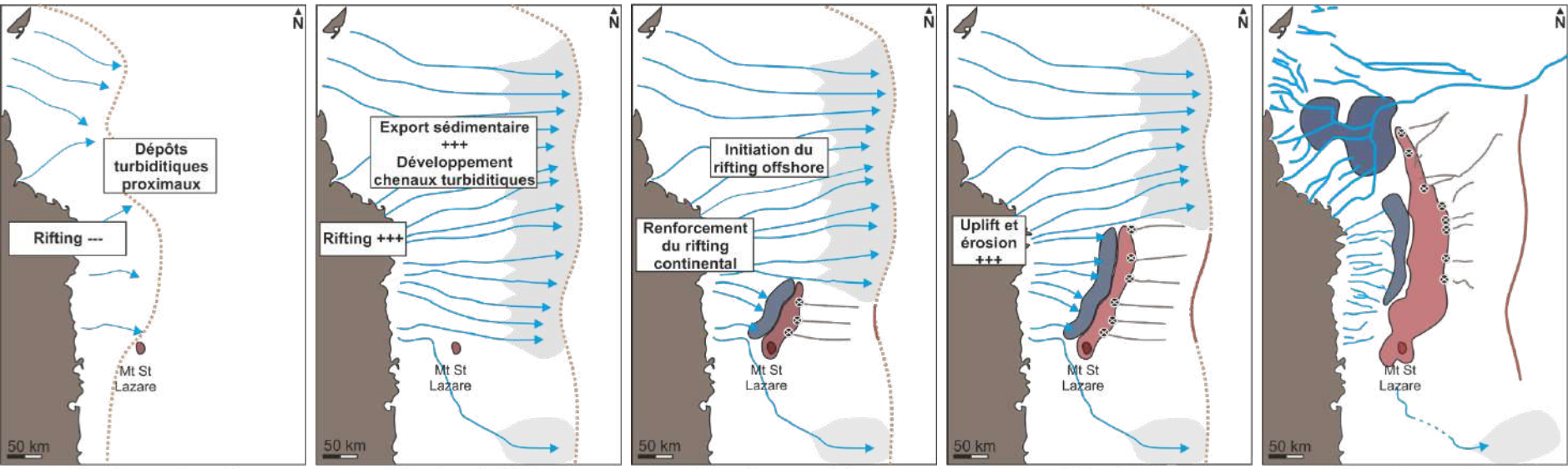
Autoroutes SHOM (2010)



Chenal de Rufiji  
 Chenal de Tanzanie  
 Chenal Mtwara  
 Chenal de Nyéréré

Post Miocène  
 inférieur (23 millions  
 d'années)





Paléocène-Oligocène

~Miocène inférieur

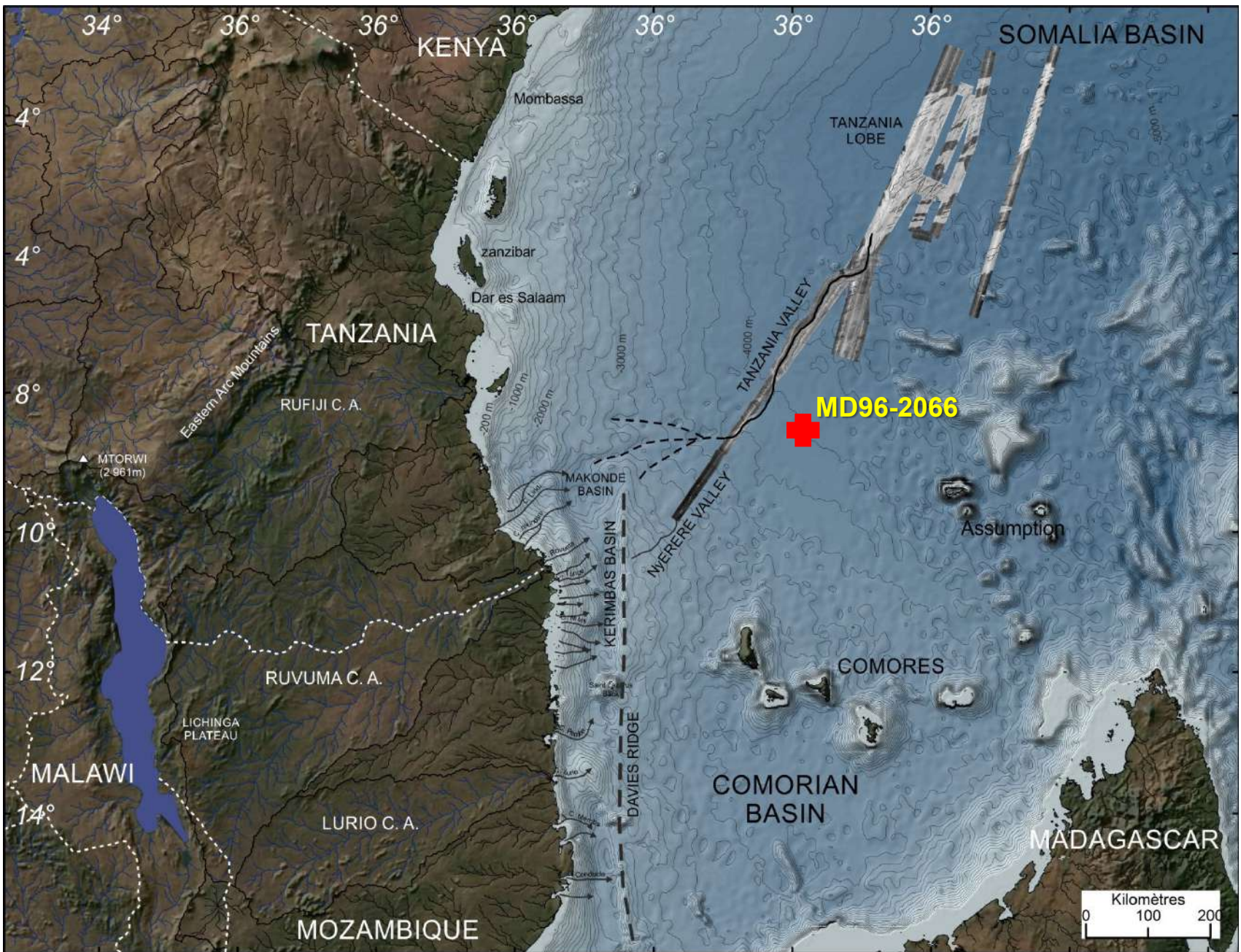
~Miocène supérieur

~Pliocène

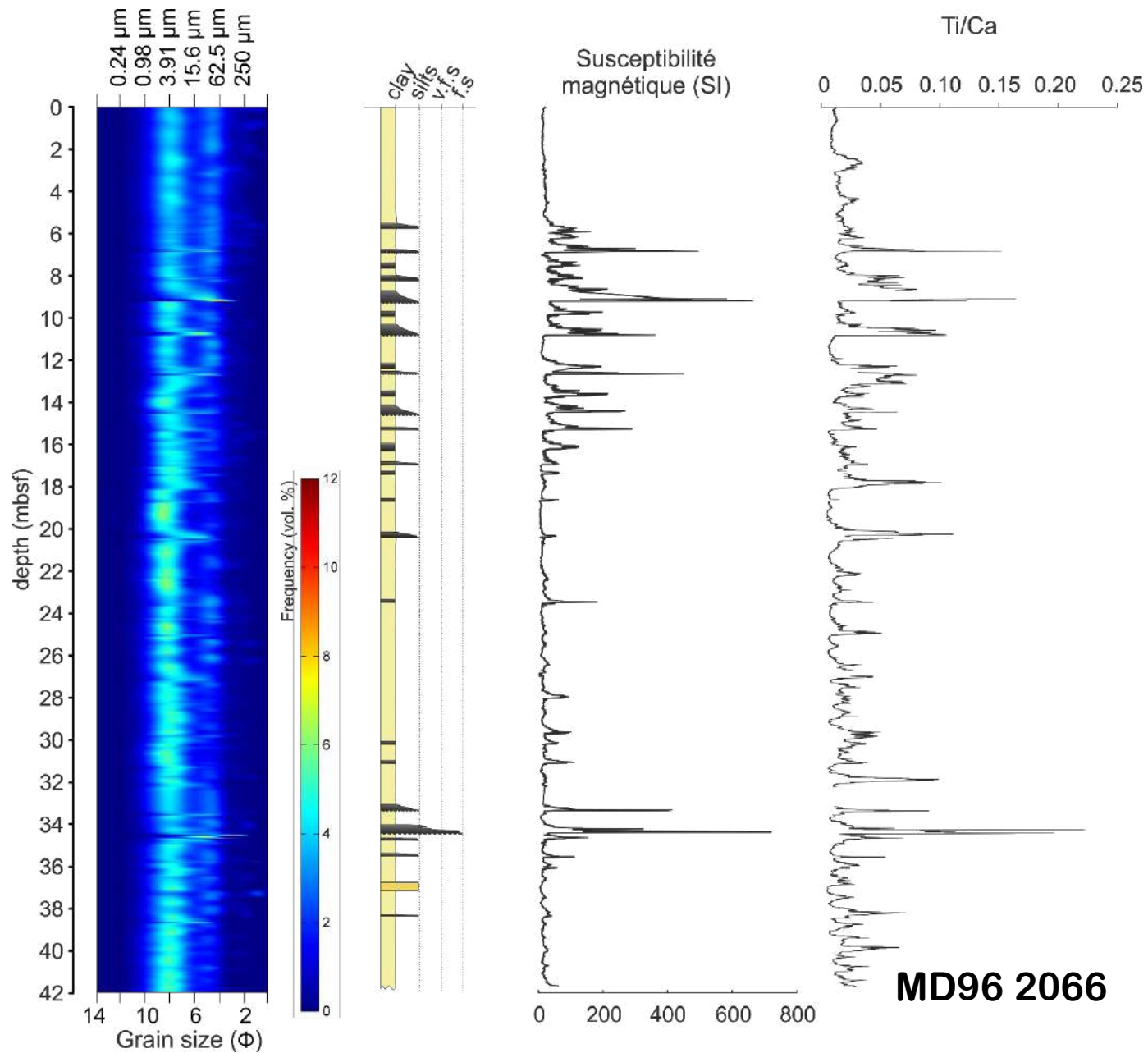
~Pléistocène-Récent

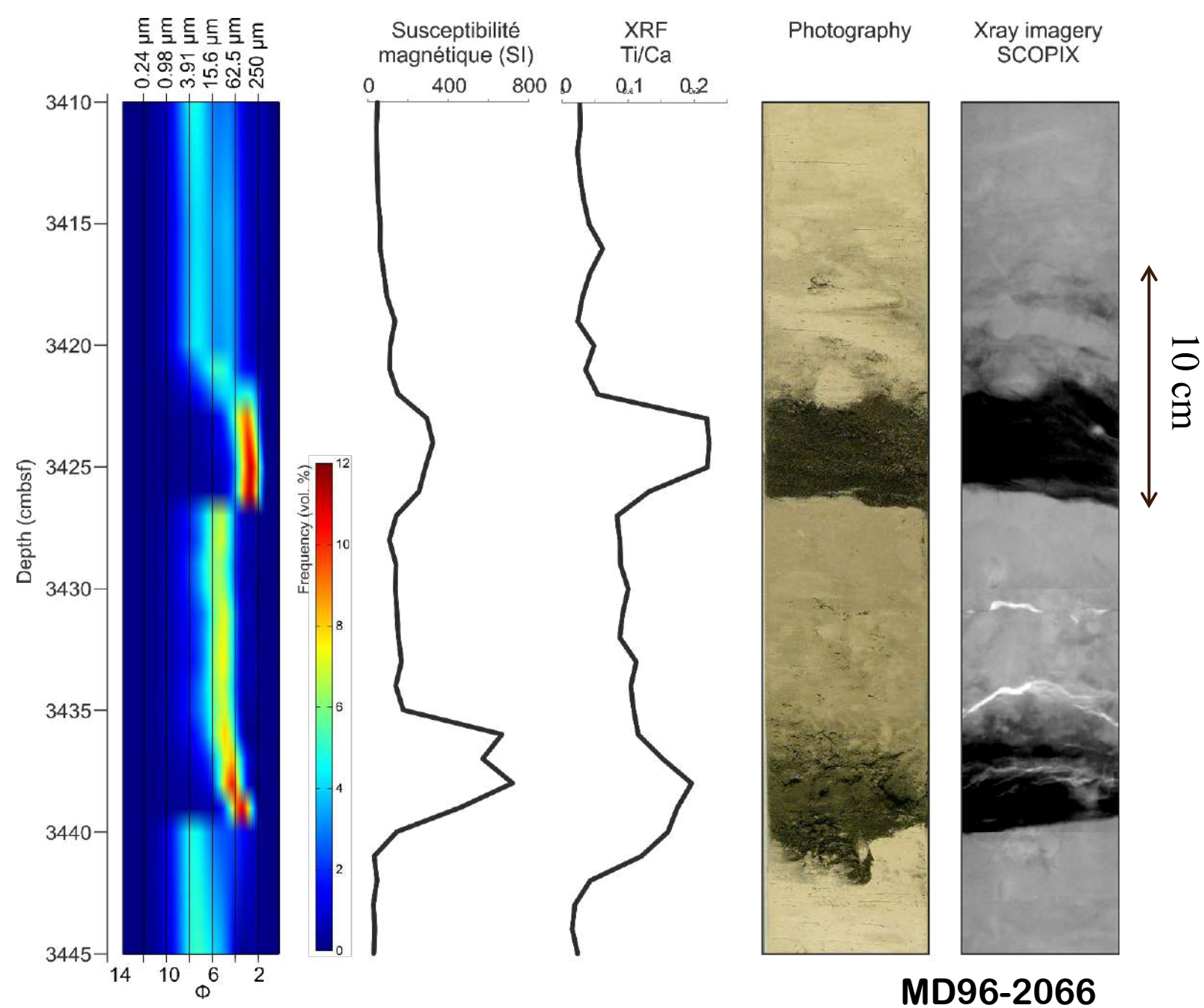
Léa Fournier 2016





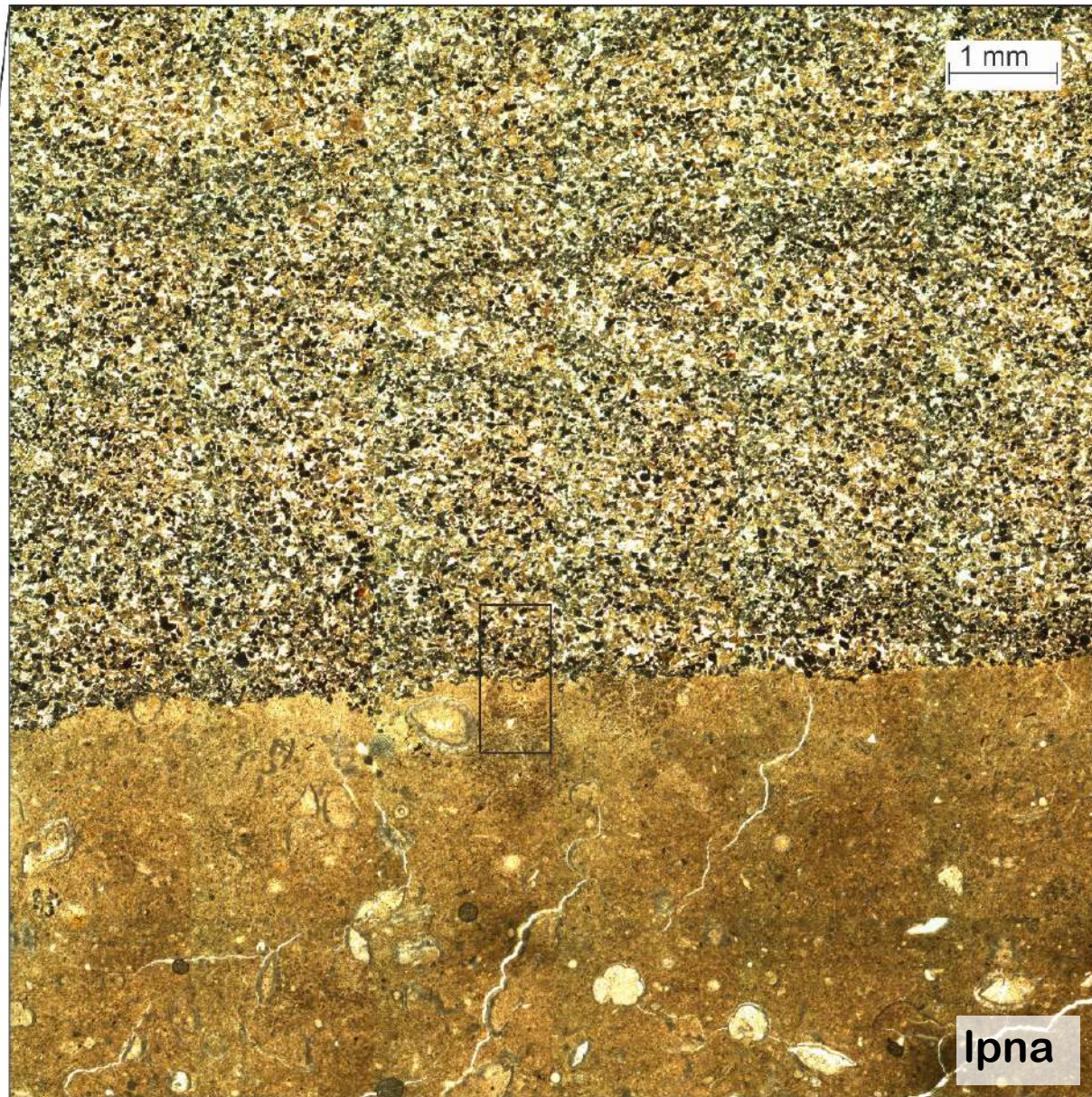






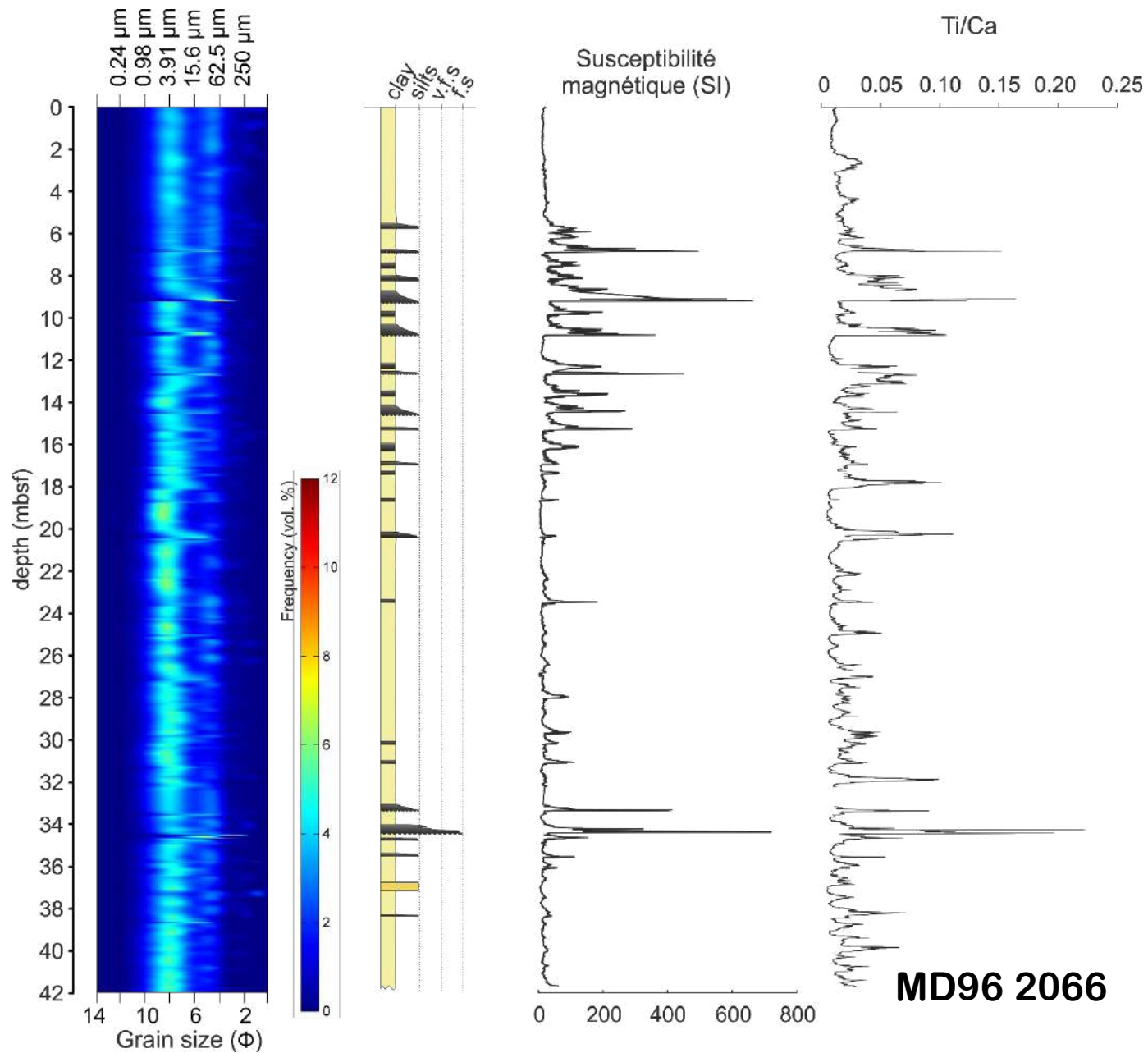
MD96-2066





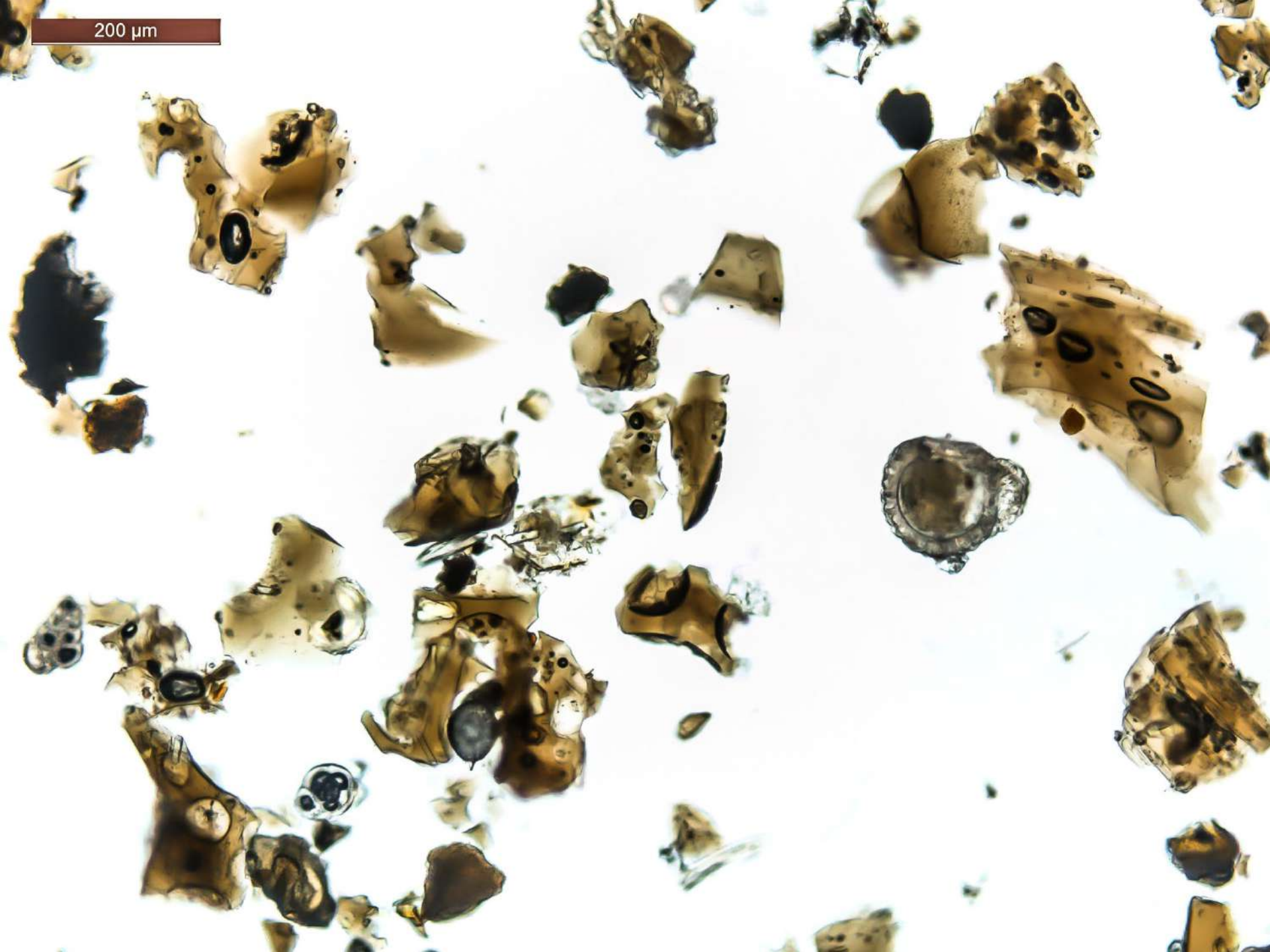
MD96-2066







200  $\mu\text{m}$

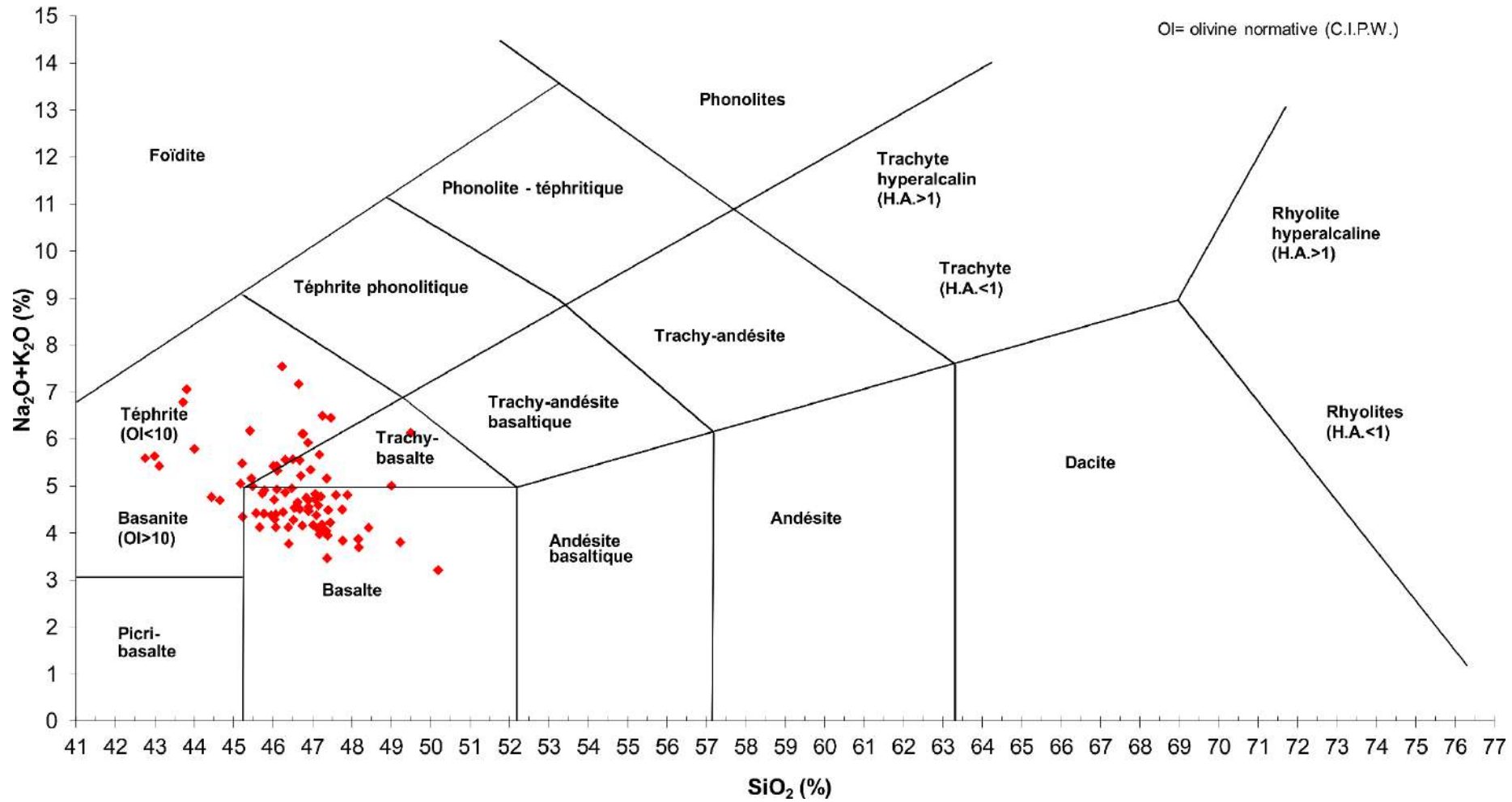


# MD96-2066

Classification des laves  
selon Lebas, Le Maître, Streckeisen et Zanettin (1986).

$H.A. = \text{mol}(\text{Na}_2\text{O} + \text{K}_2\text{O}) / \text{Al}_2\text{O}_3$

Ol = olivine normative (C.I.P.W.)

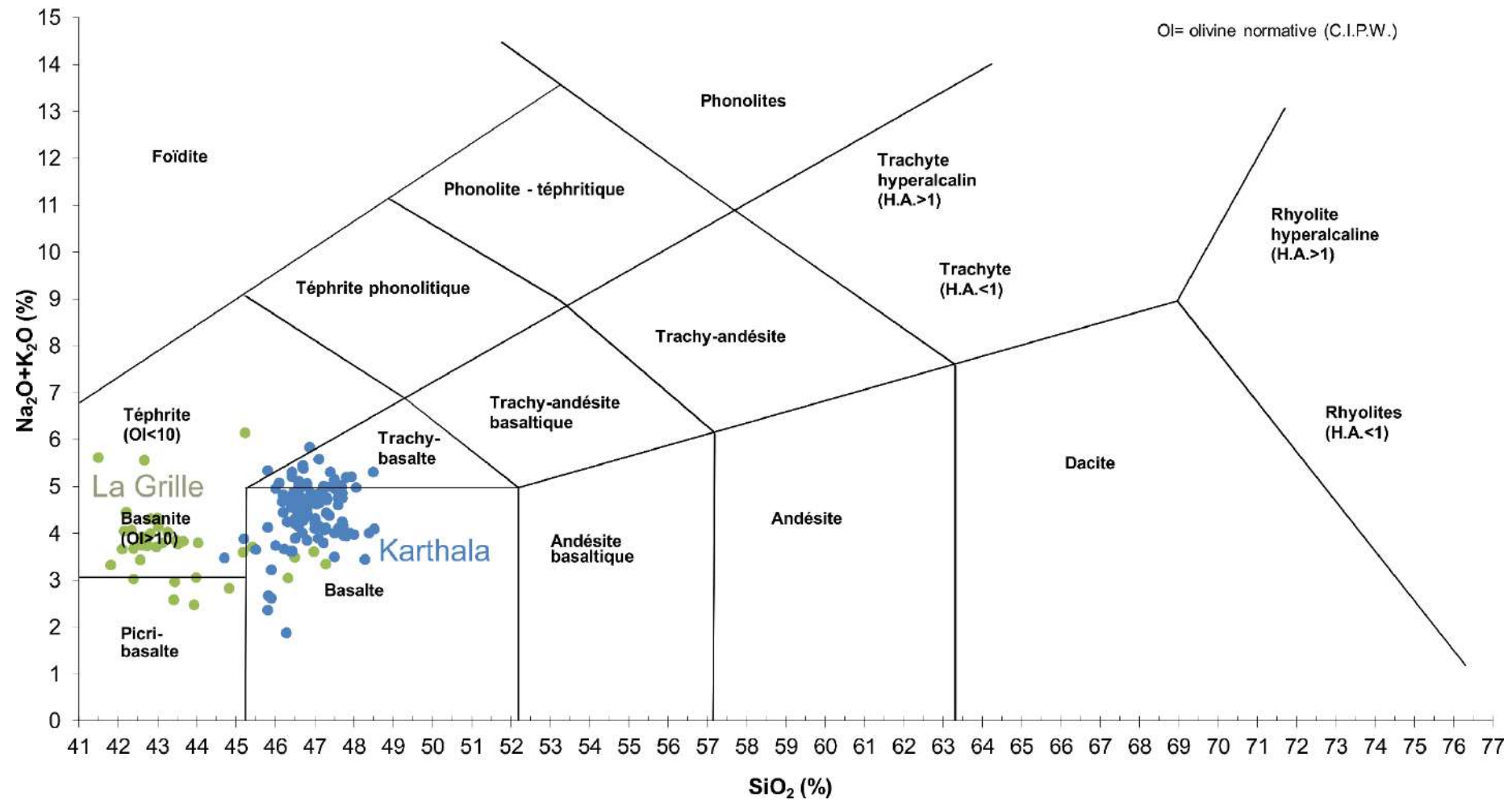




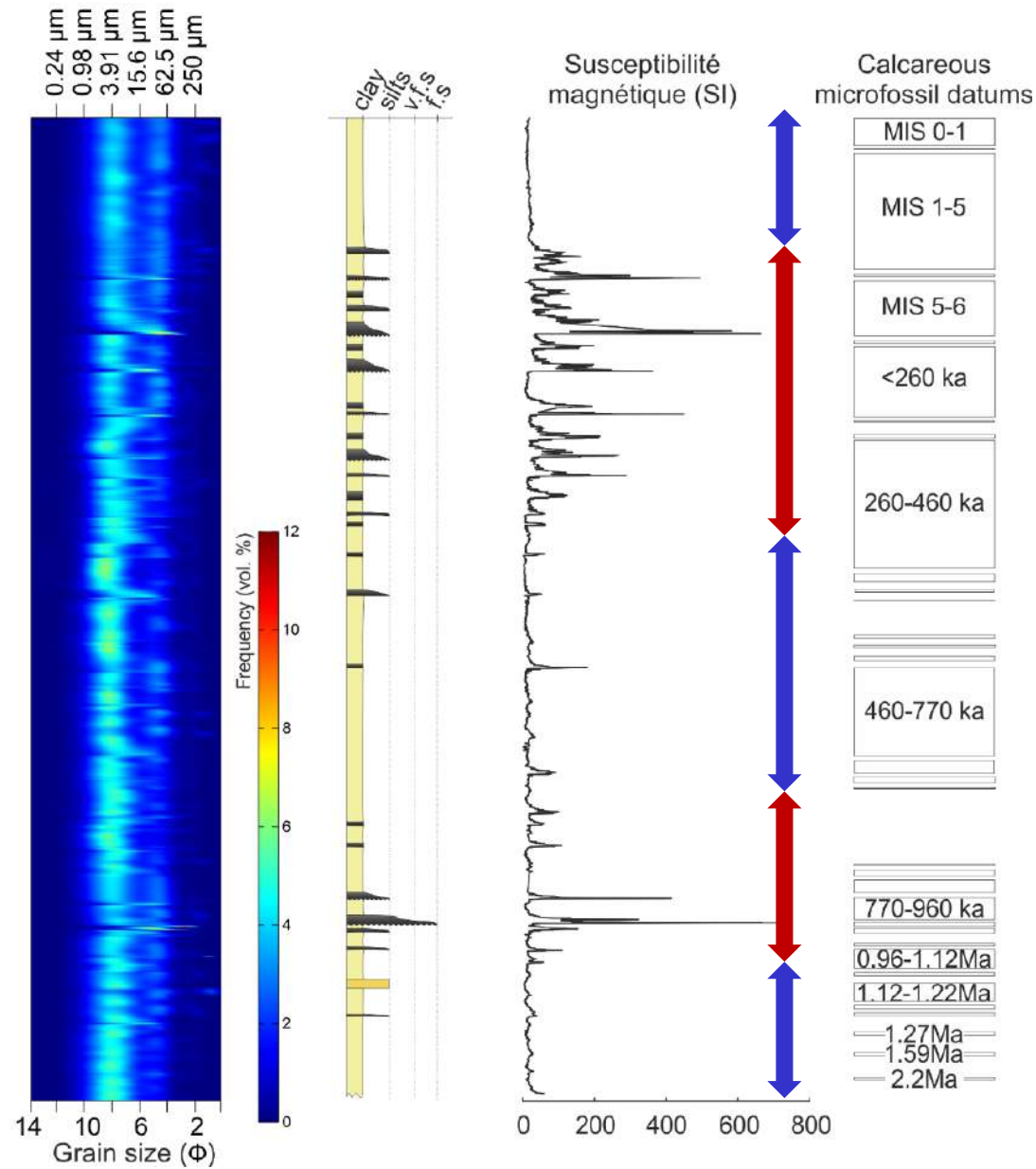
# GRANDE COMORE selon Lebas, Le Maître, Streckeisen et Zanettin (1986).

H.A.=  $\text{mol}(\text{Na}_2\text{O}+\text{K}_2\text{O})/\text{Al}_2\text{O}_3$

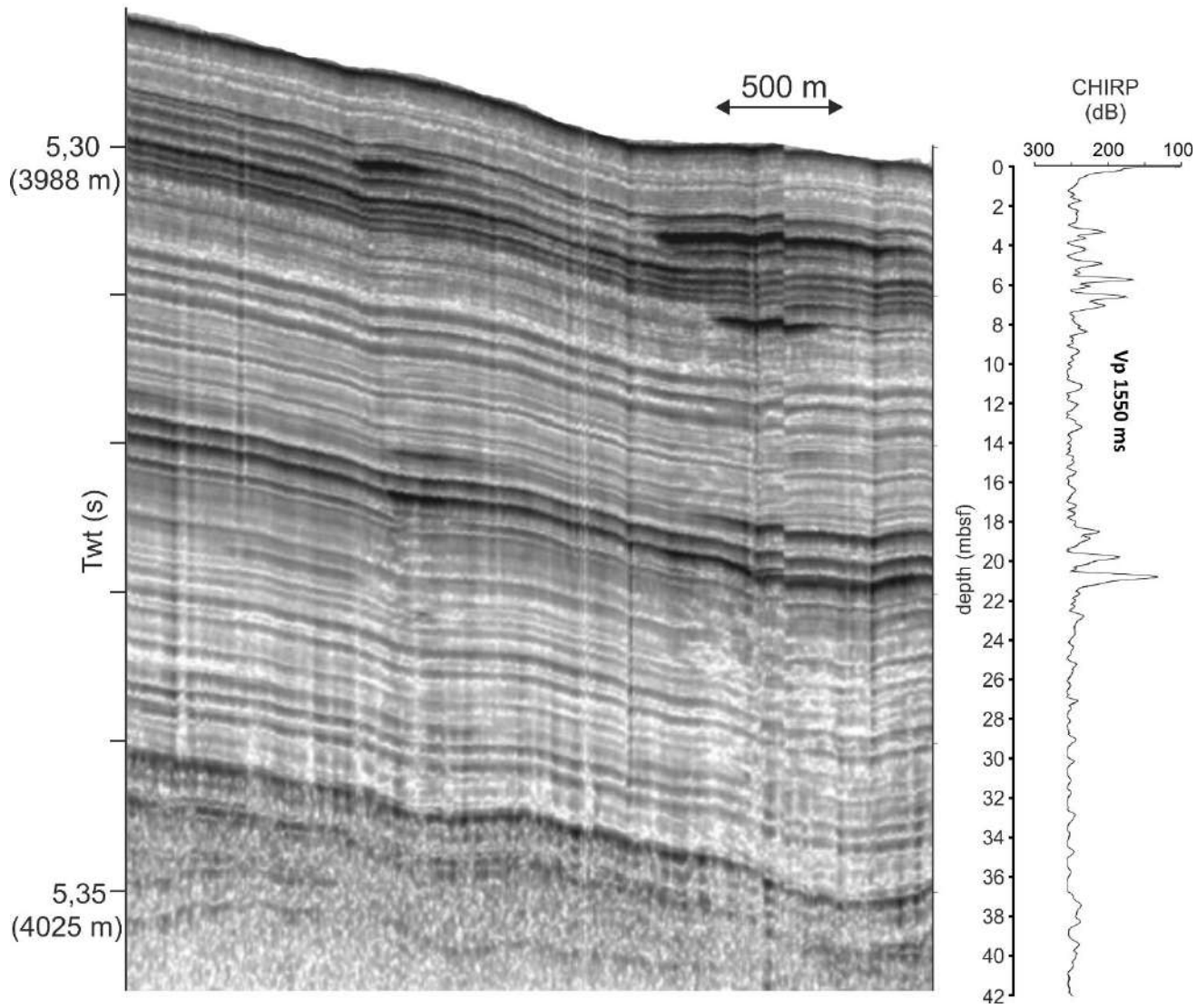
OI= olivine normative (C.I.P.W.)

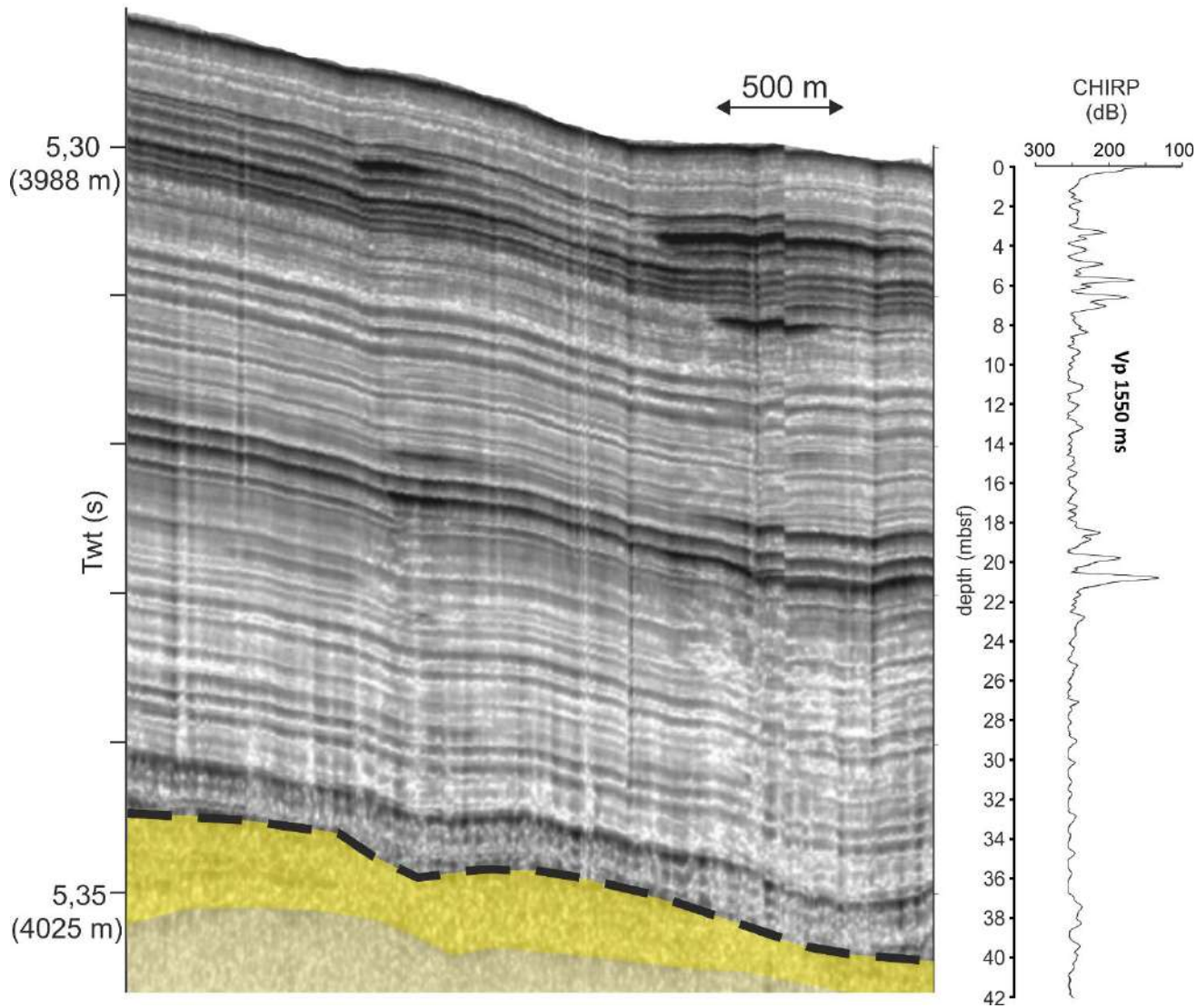


# MD96-2066

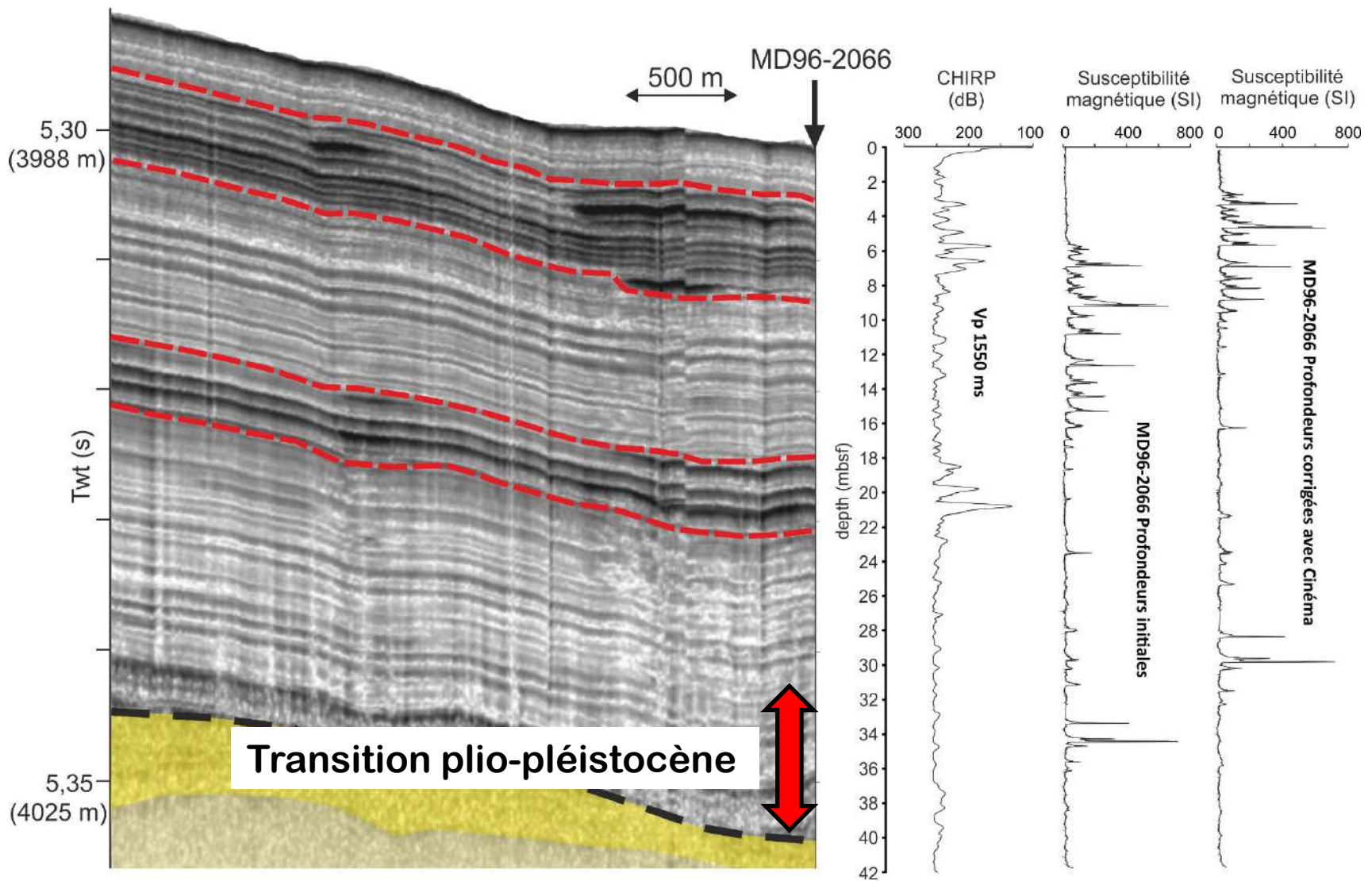


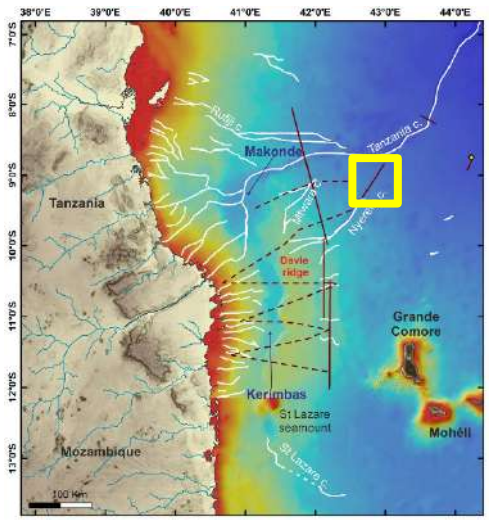
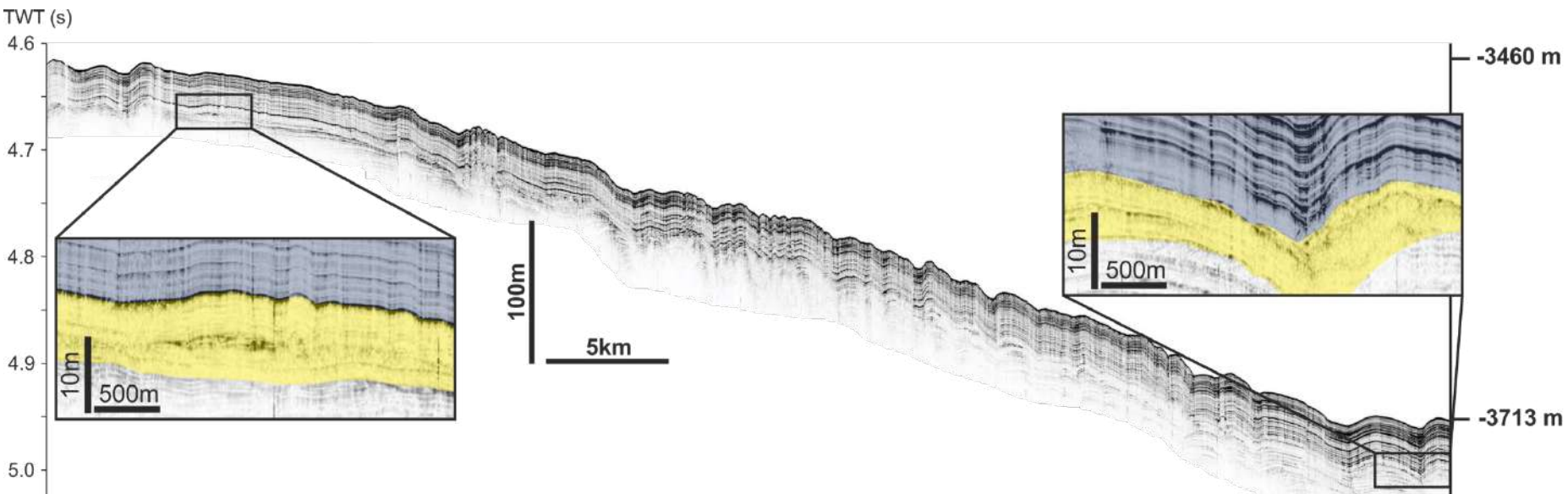




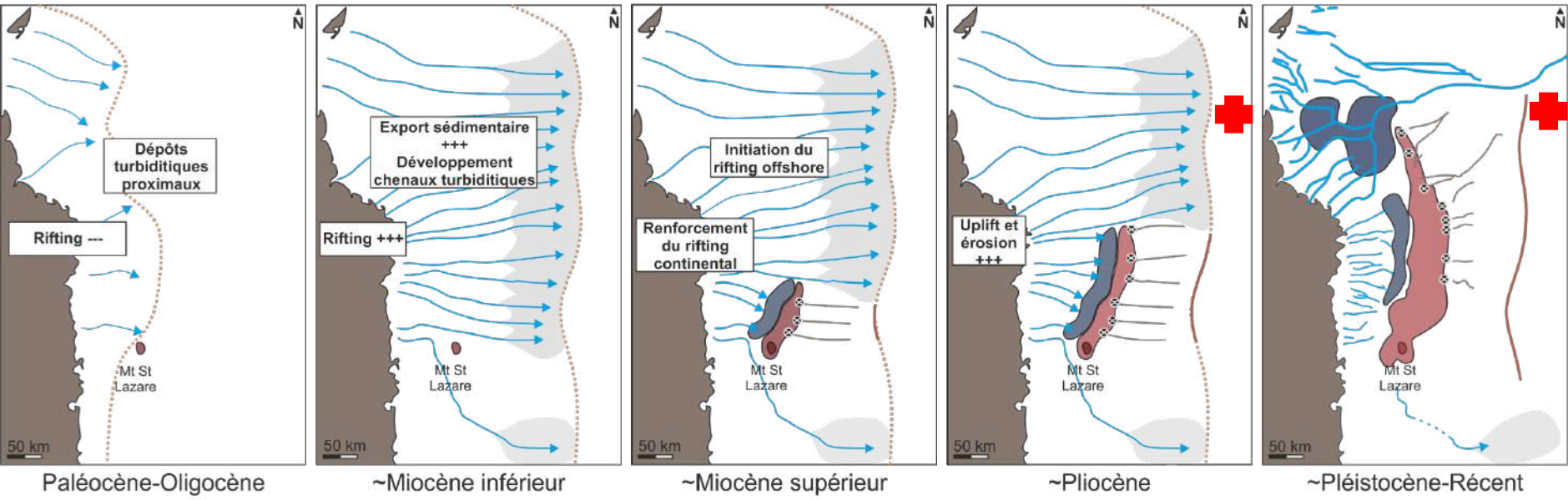






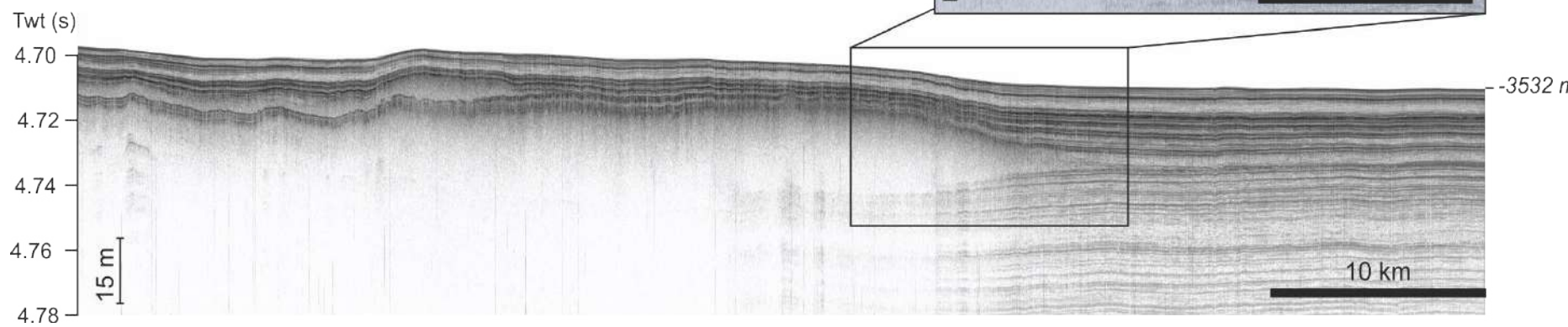
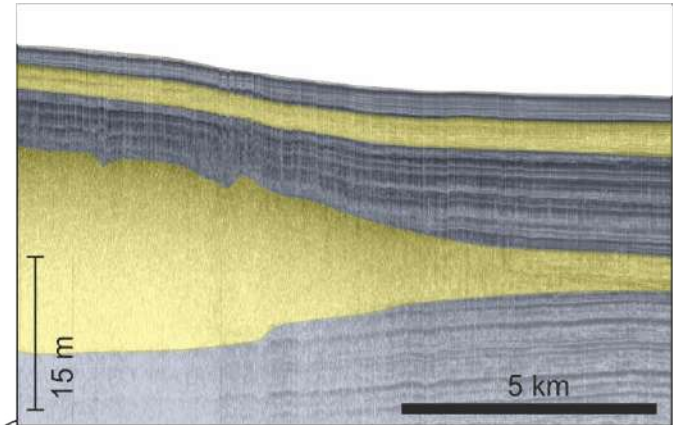
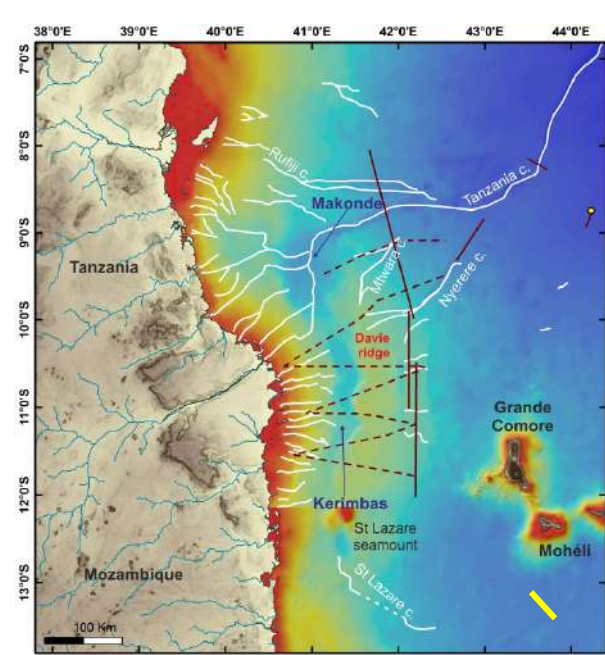




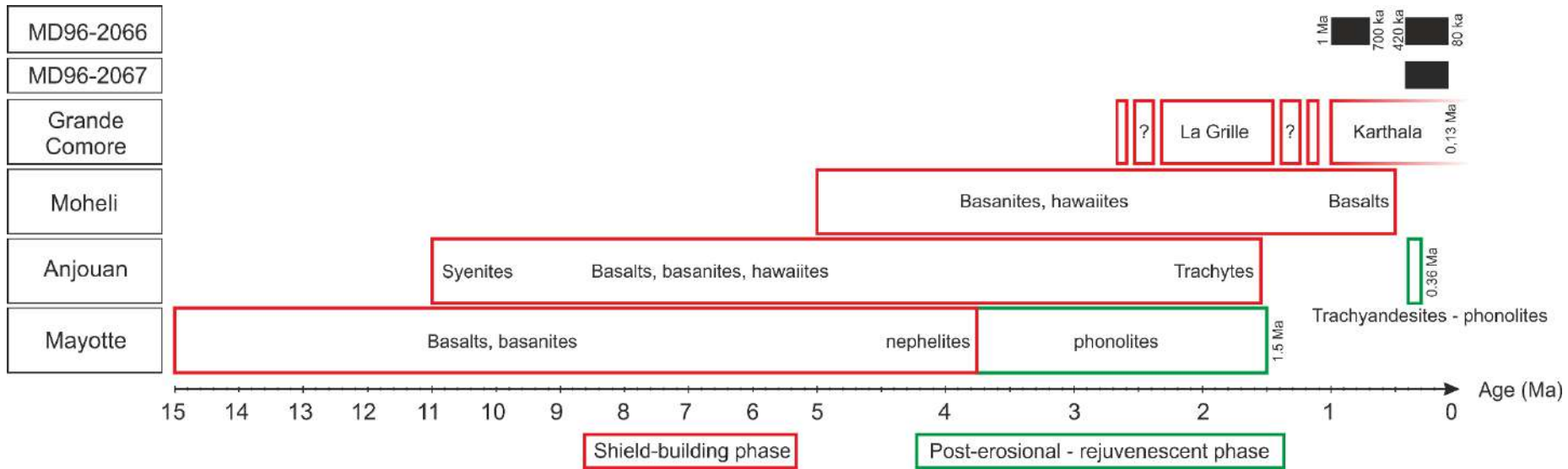


Léa Fournier 2016

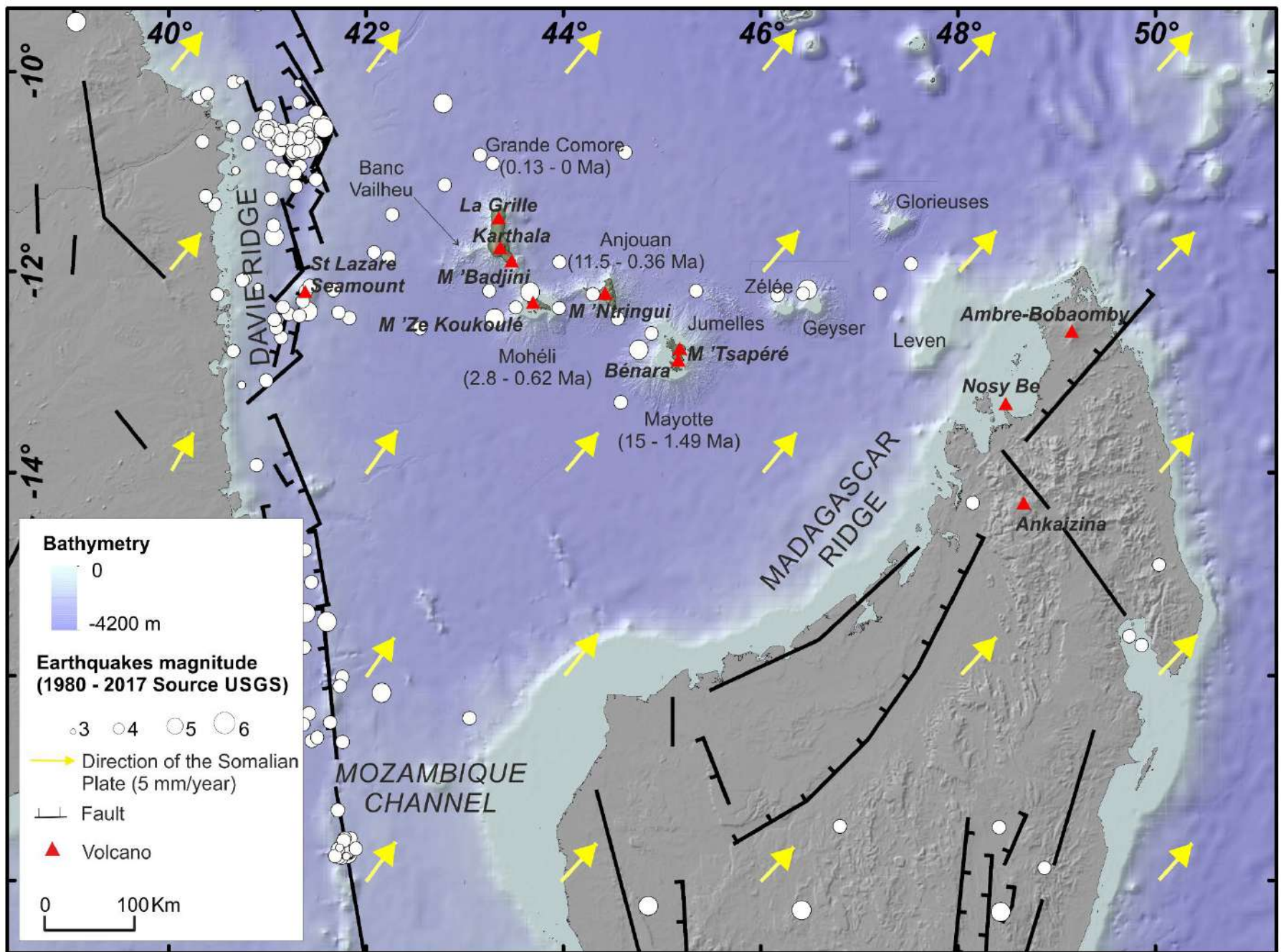




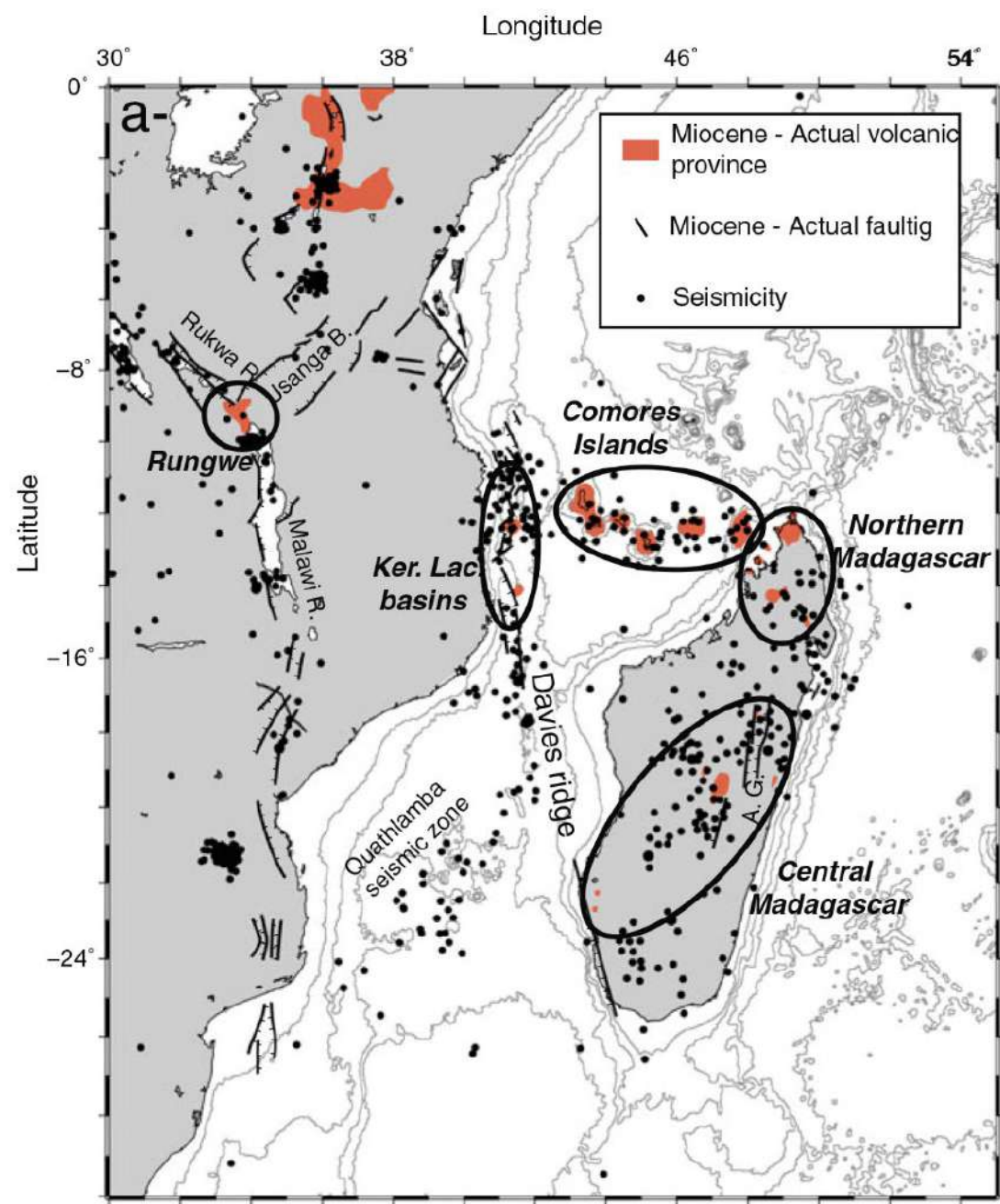




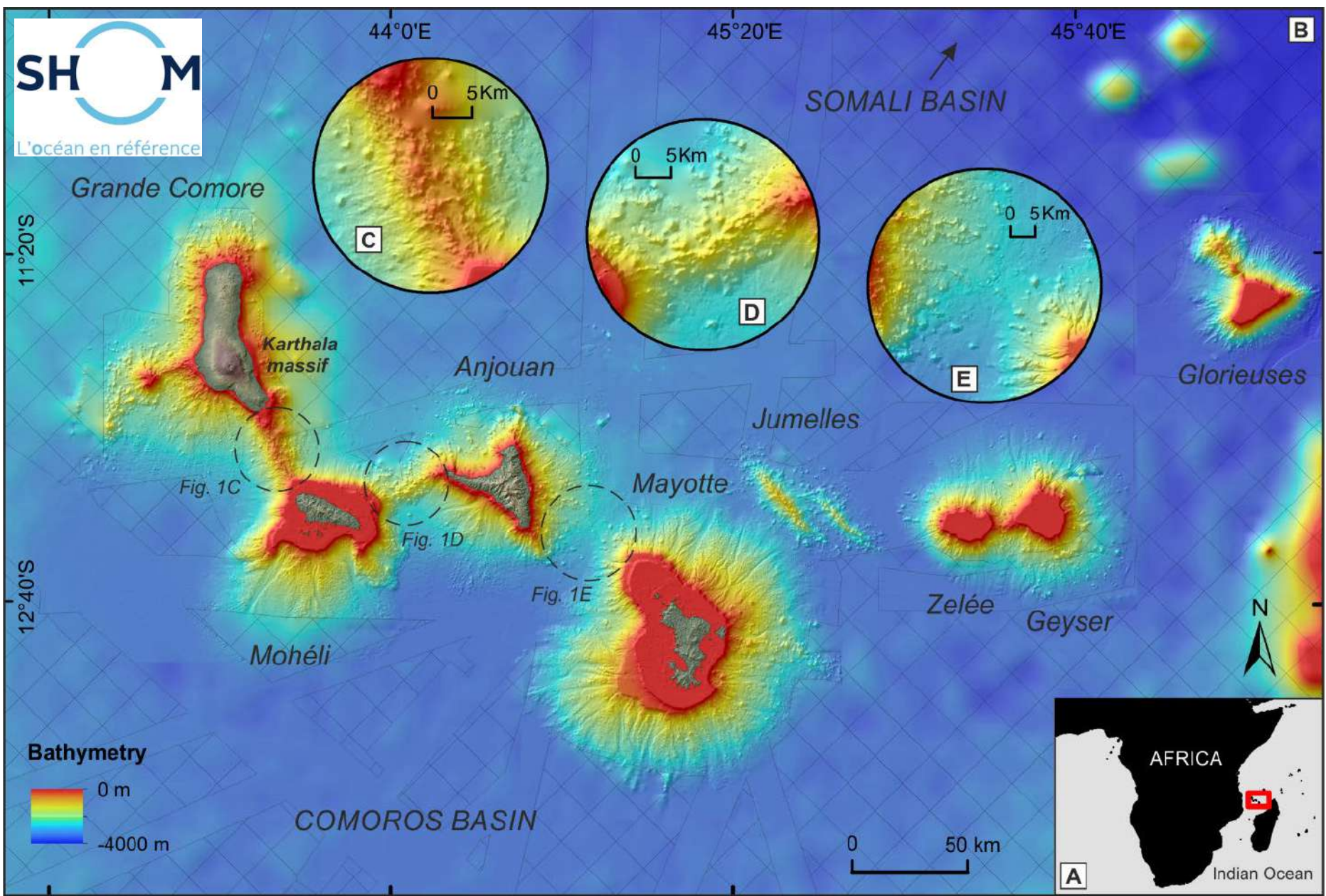
Audru, J.-C. et al. 2006 ; Spath, A. et al. 1996 ; Nougier, J. et al. 1986 ; Emerick, C.M., Duncan, R.A., 1982





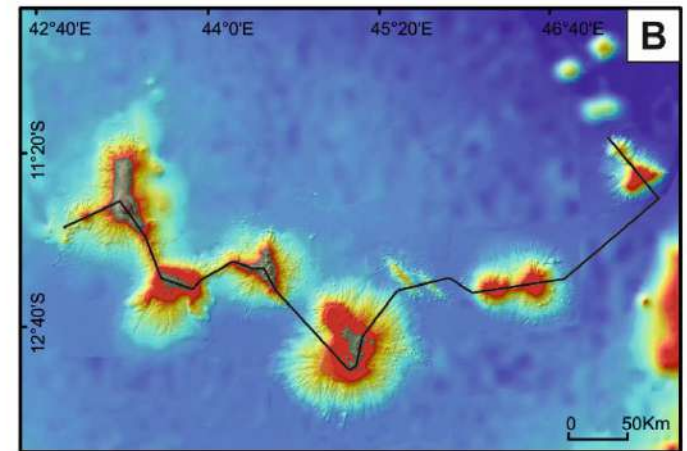
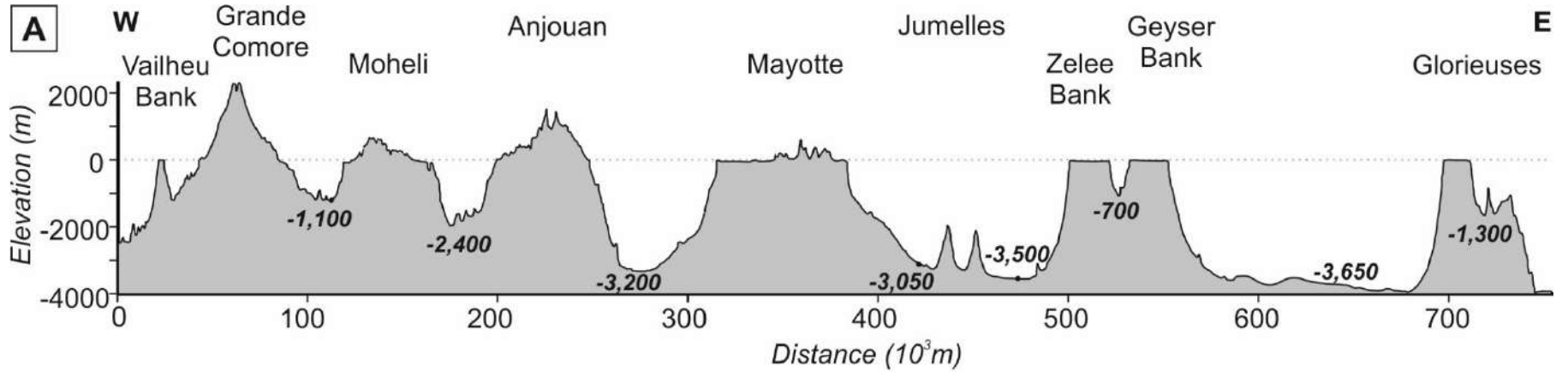


Bachelery, Patrick, Jean-François Lenat, Andrea Di Muro, et Laurent Michon, éd. Active Volcanoes of the Southwest Indian Ocean. Active Volcanoes of the World. Berlin, Heidelberg: Springer Berlin Heidelberg, 2016.



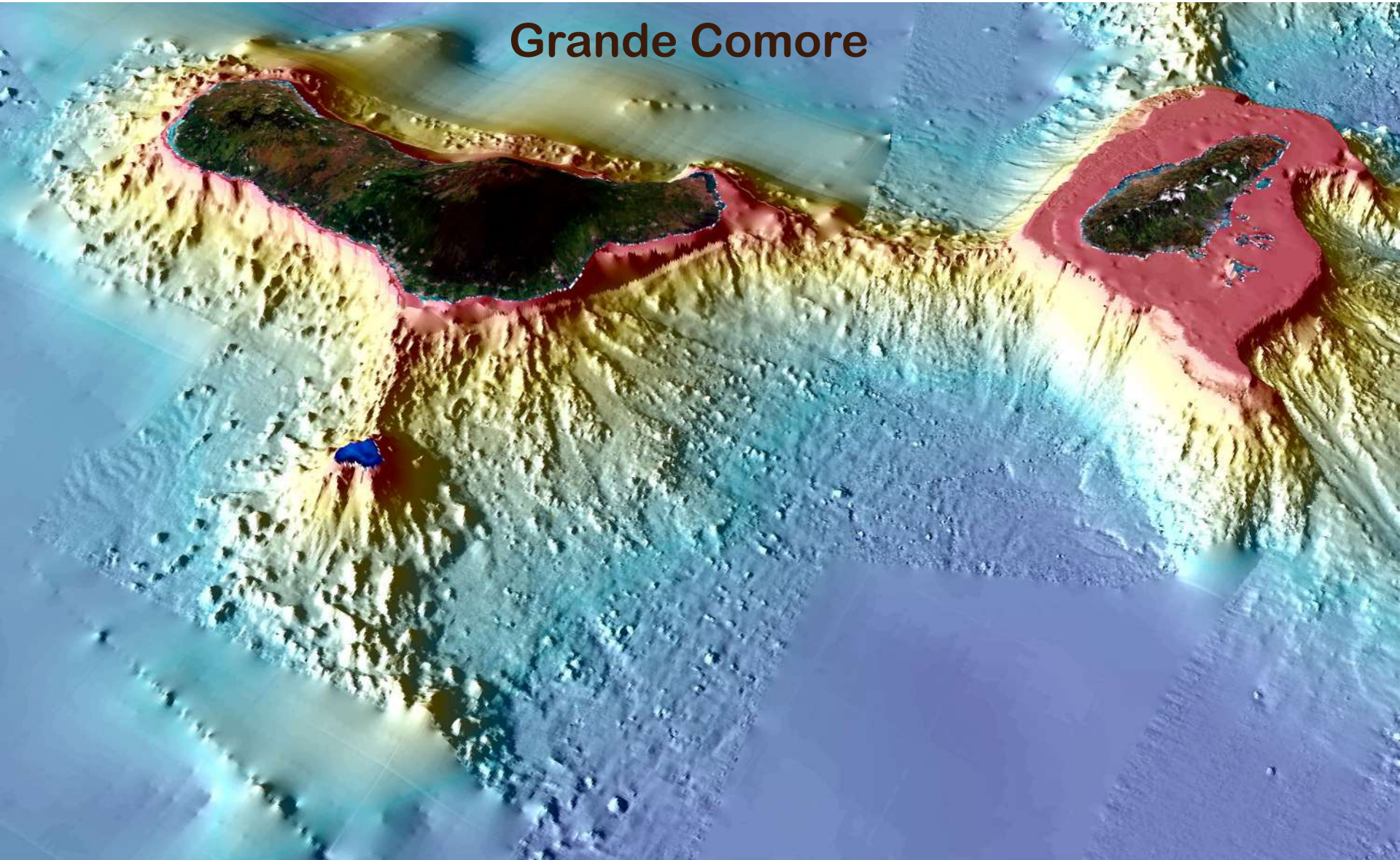
Athina Tzevahirtzian et al. 2021 Submarine morphology of the Comoros volcanic archipelago. Marine Geology





Athina Tzevahirtzian et al. 2021 Submarine morphology of the Comoros volcanic archipelago. Marine Geology

# Grande Comore

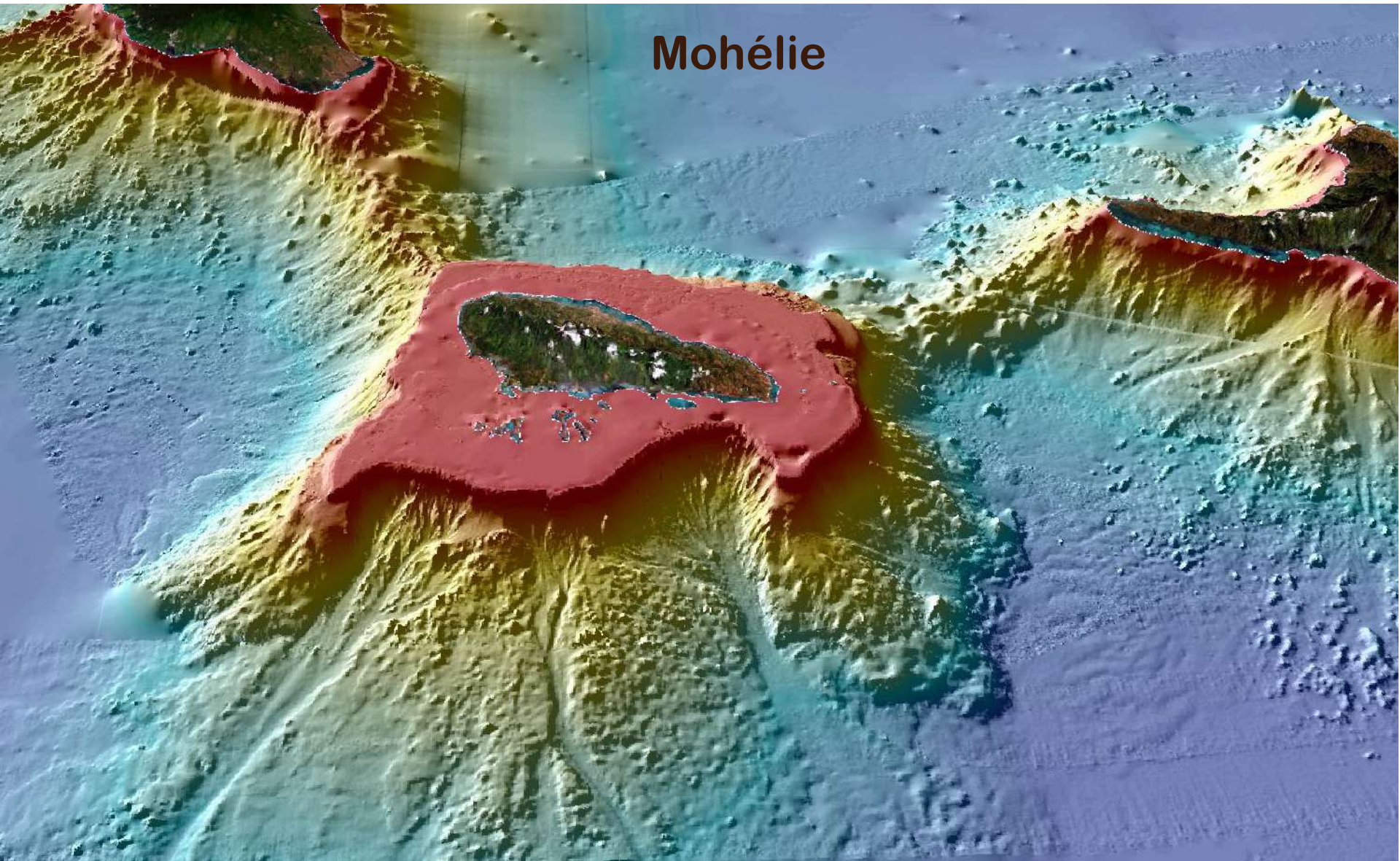






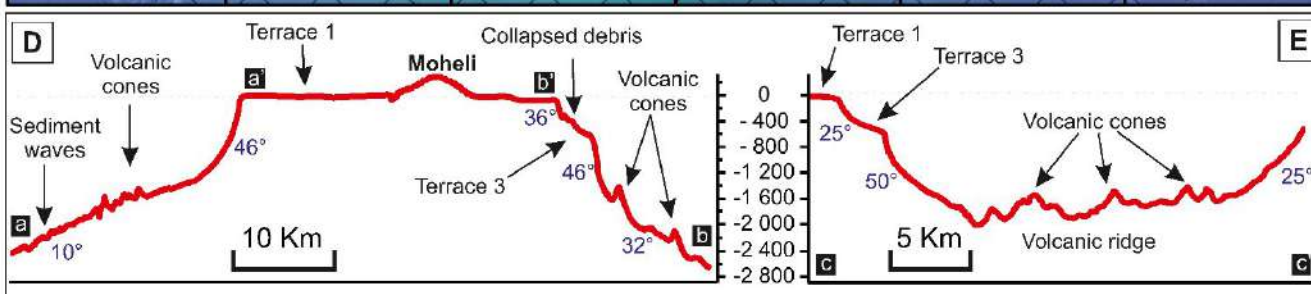
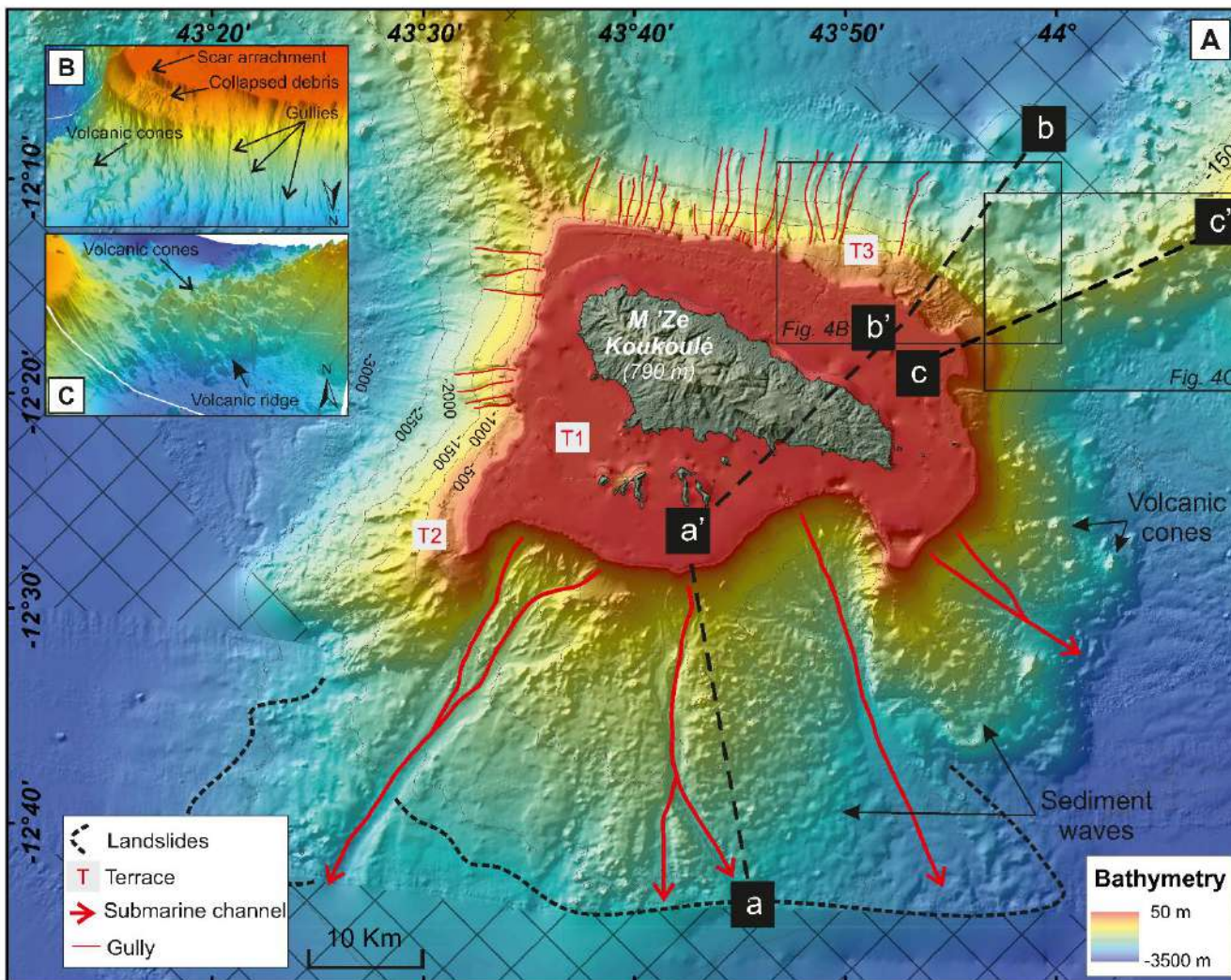


# Mohélie



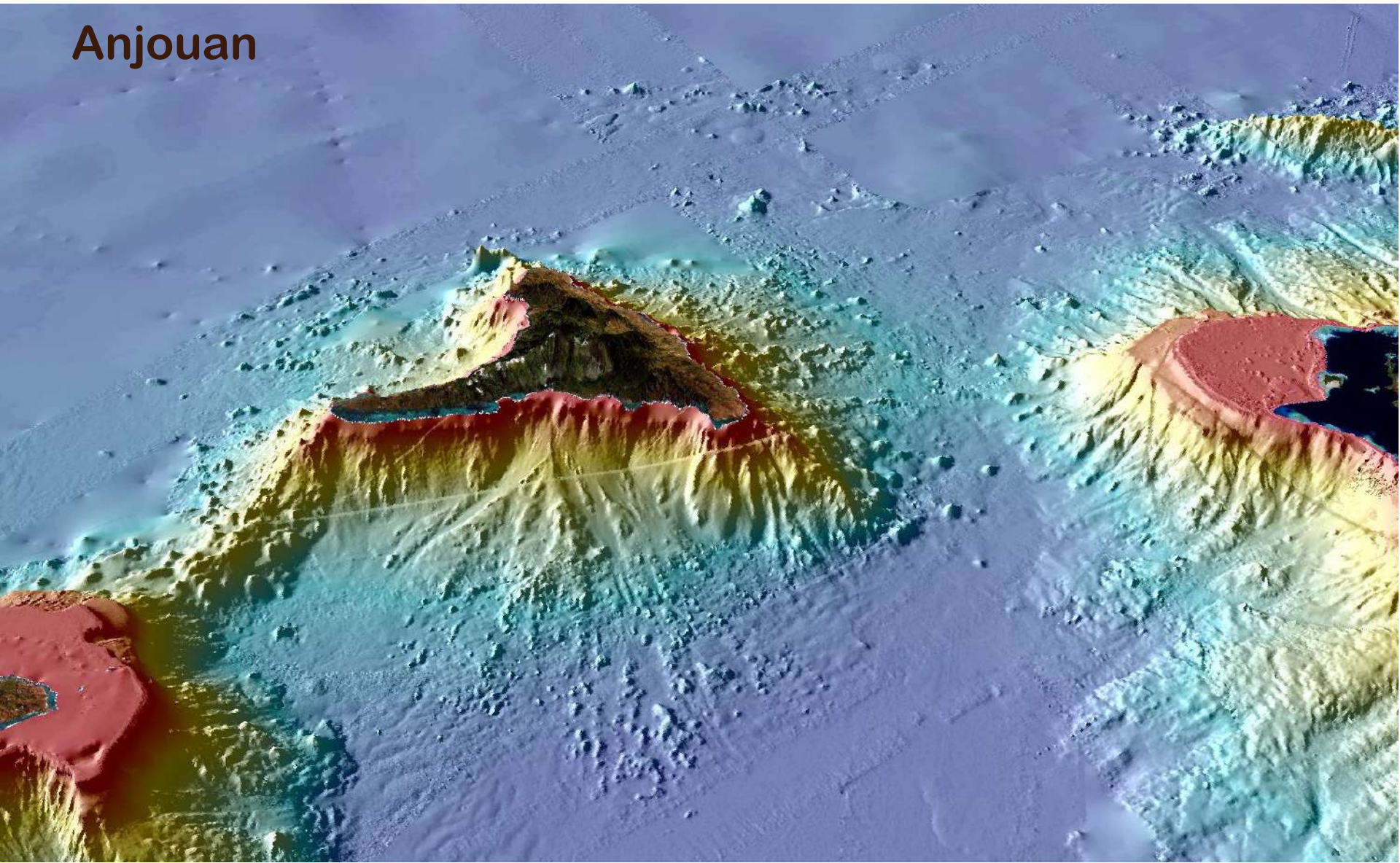


# Mohélie



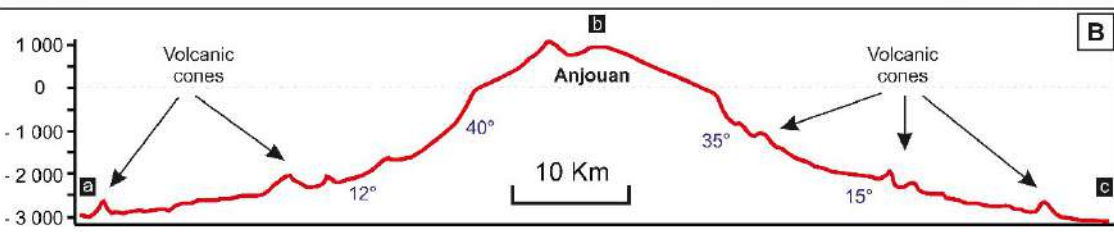
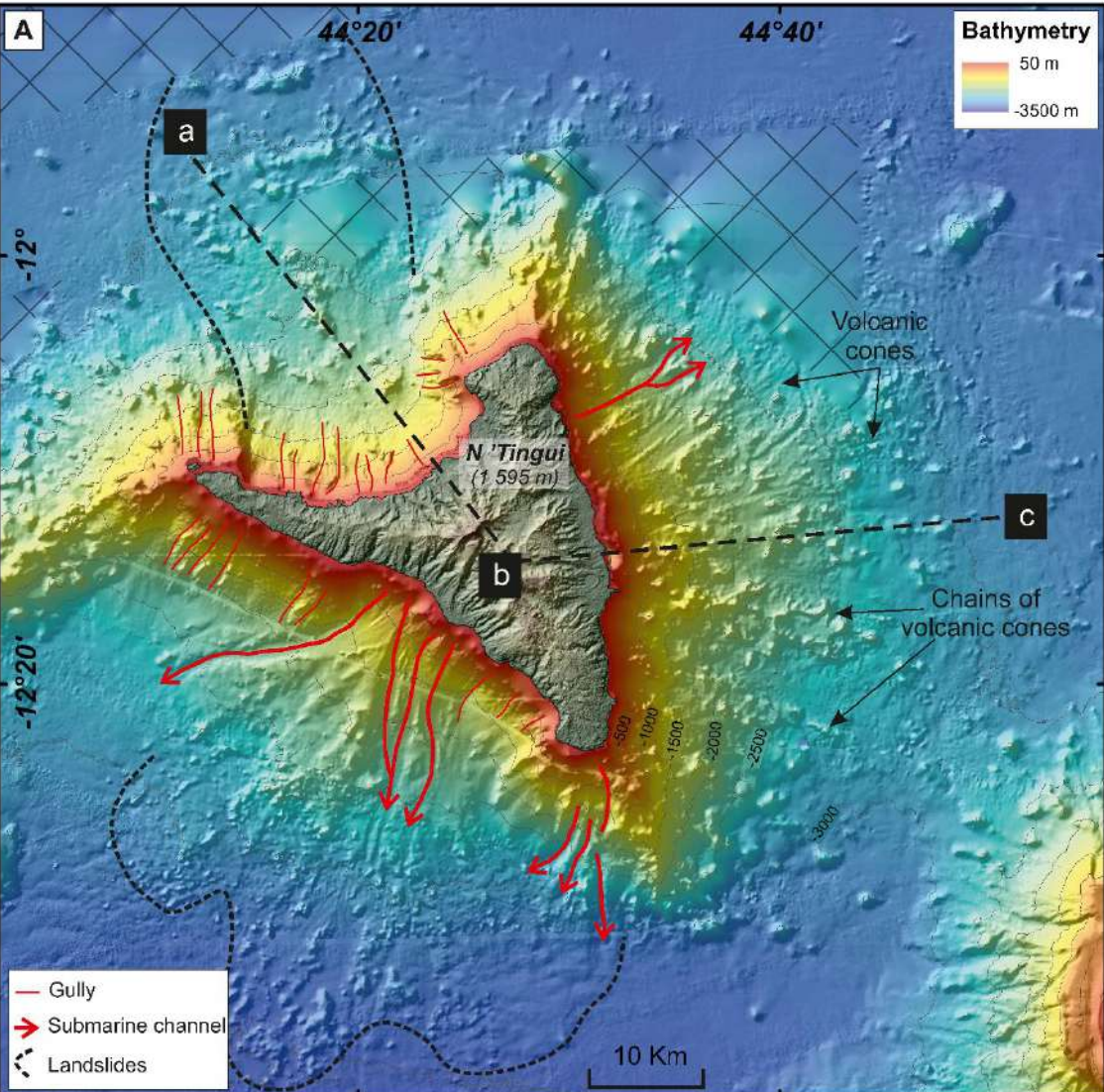


# Anjouan





# Anjouan

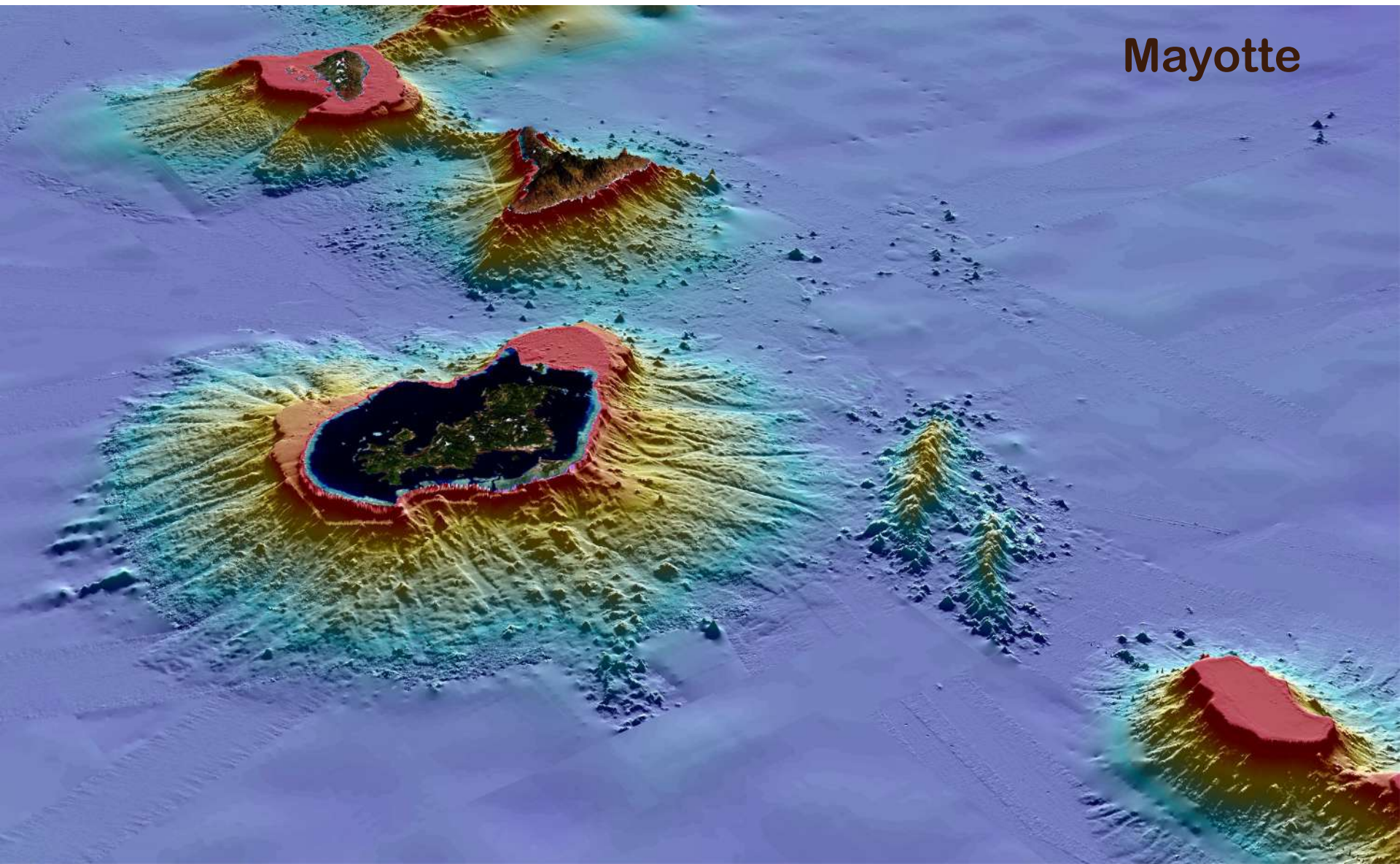


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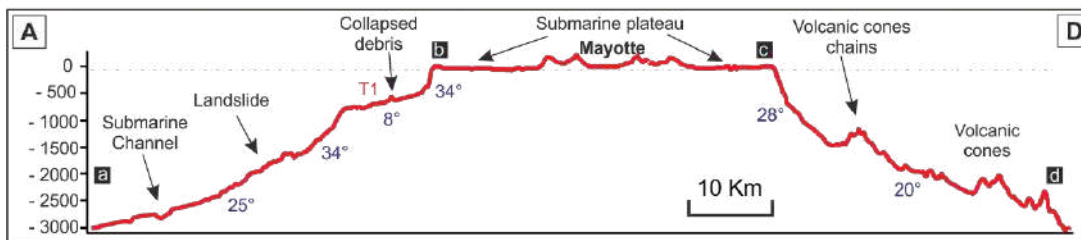
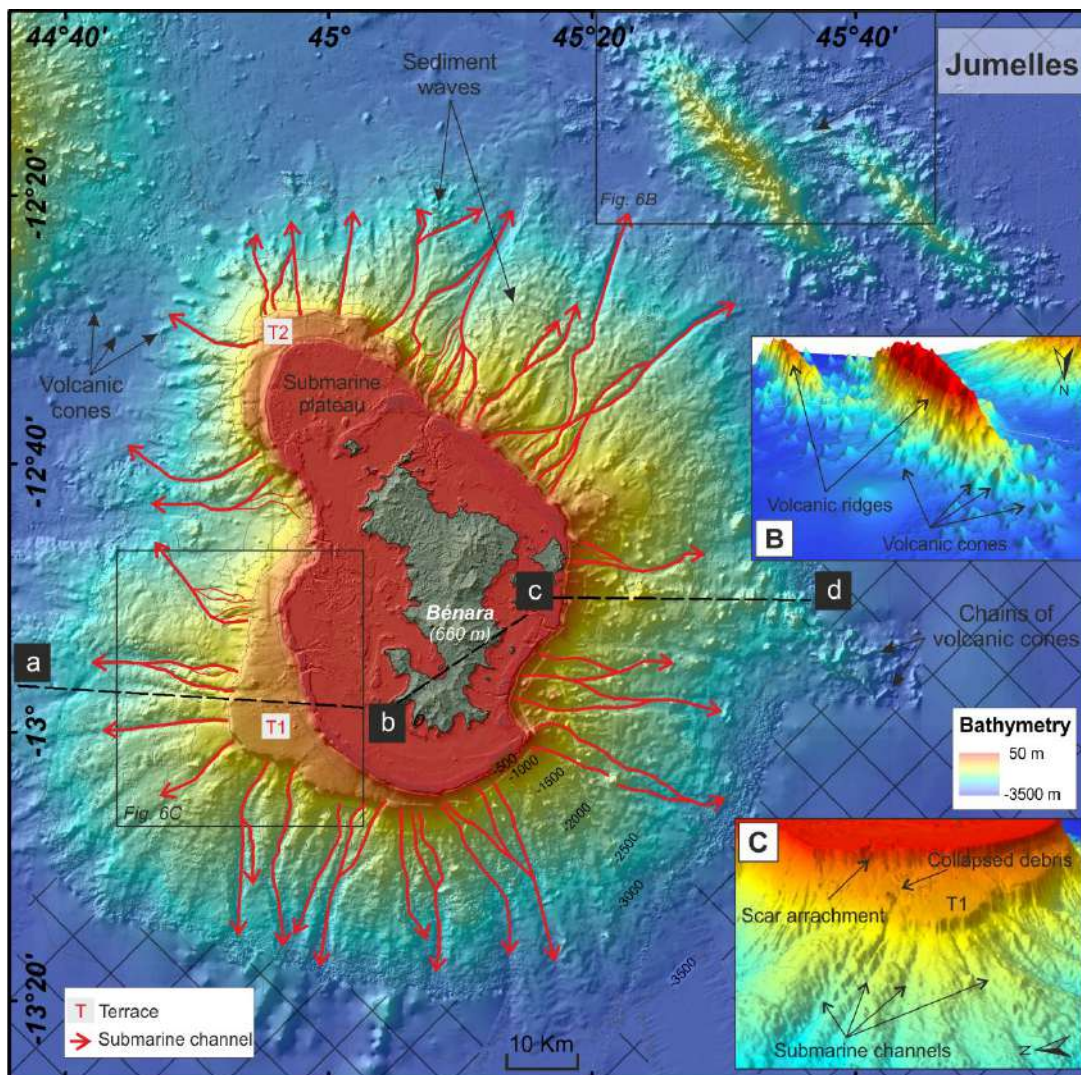


# Mayotte

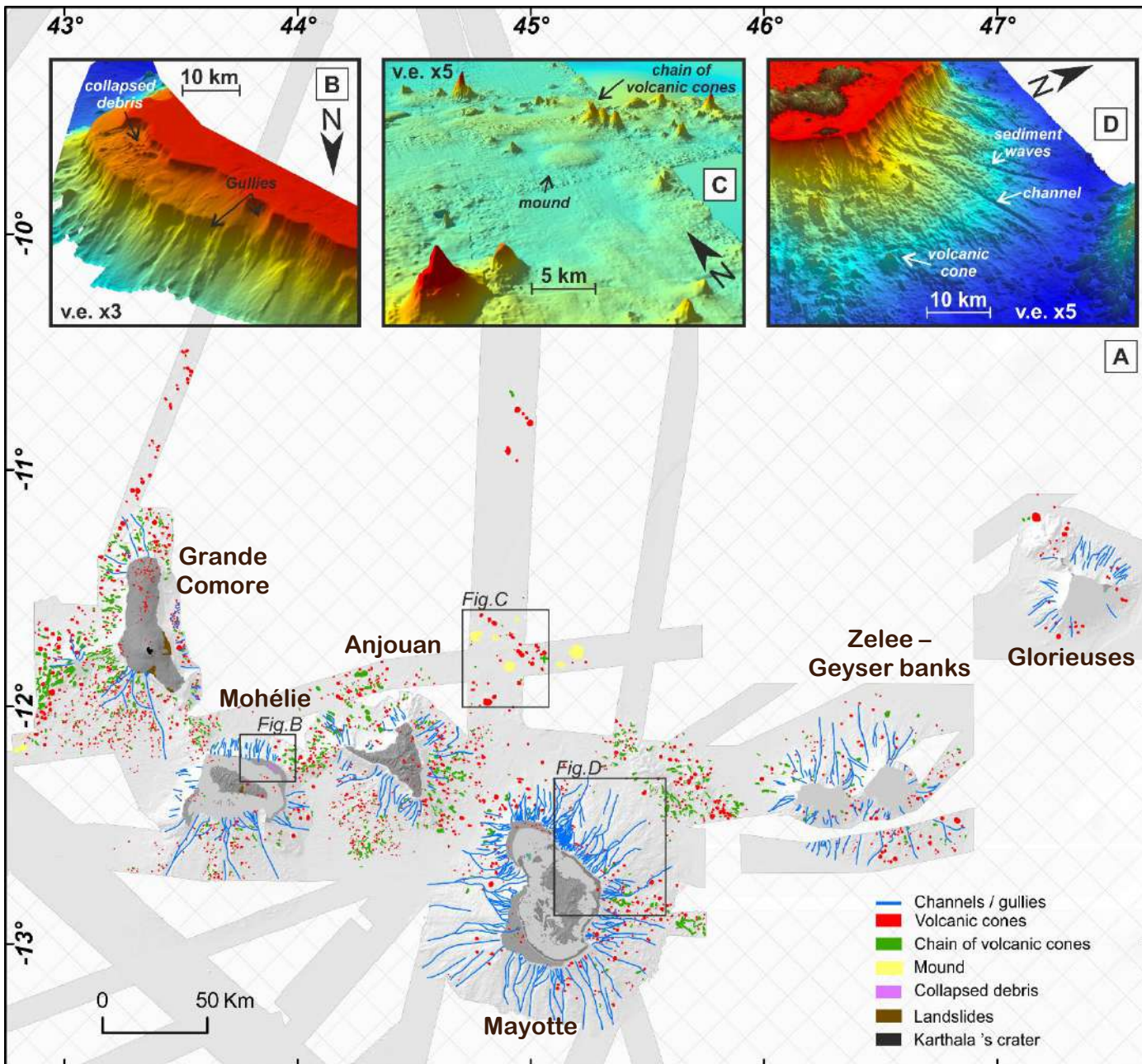




# Mayotte



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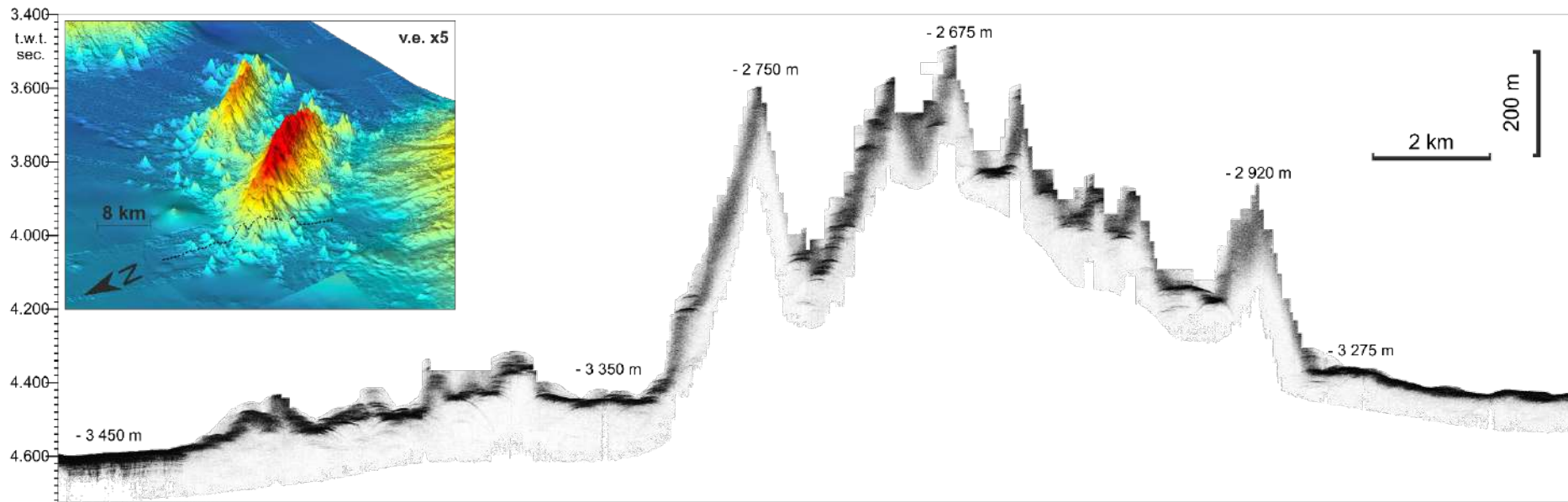
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v.e. x5

8 km

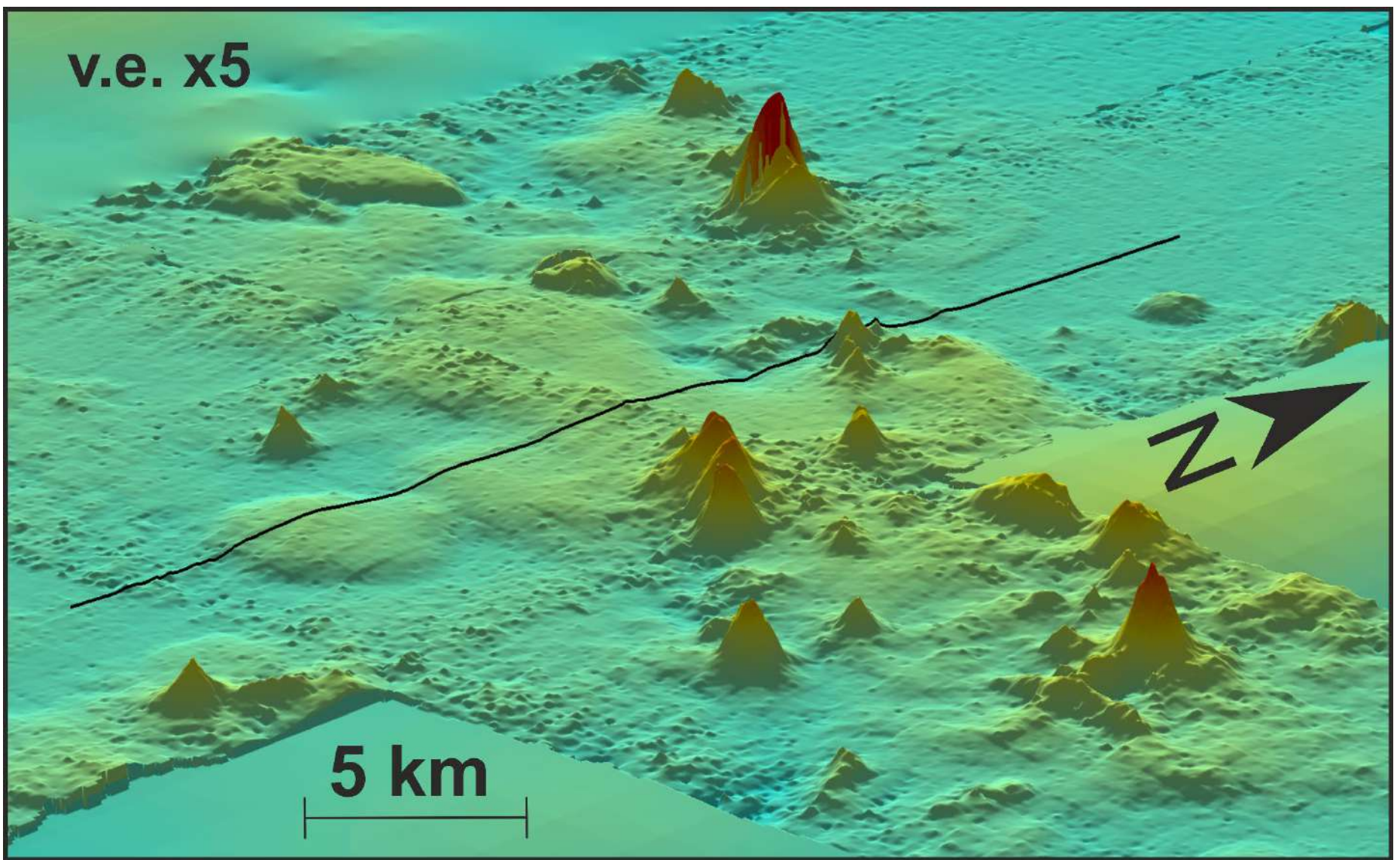




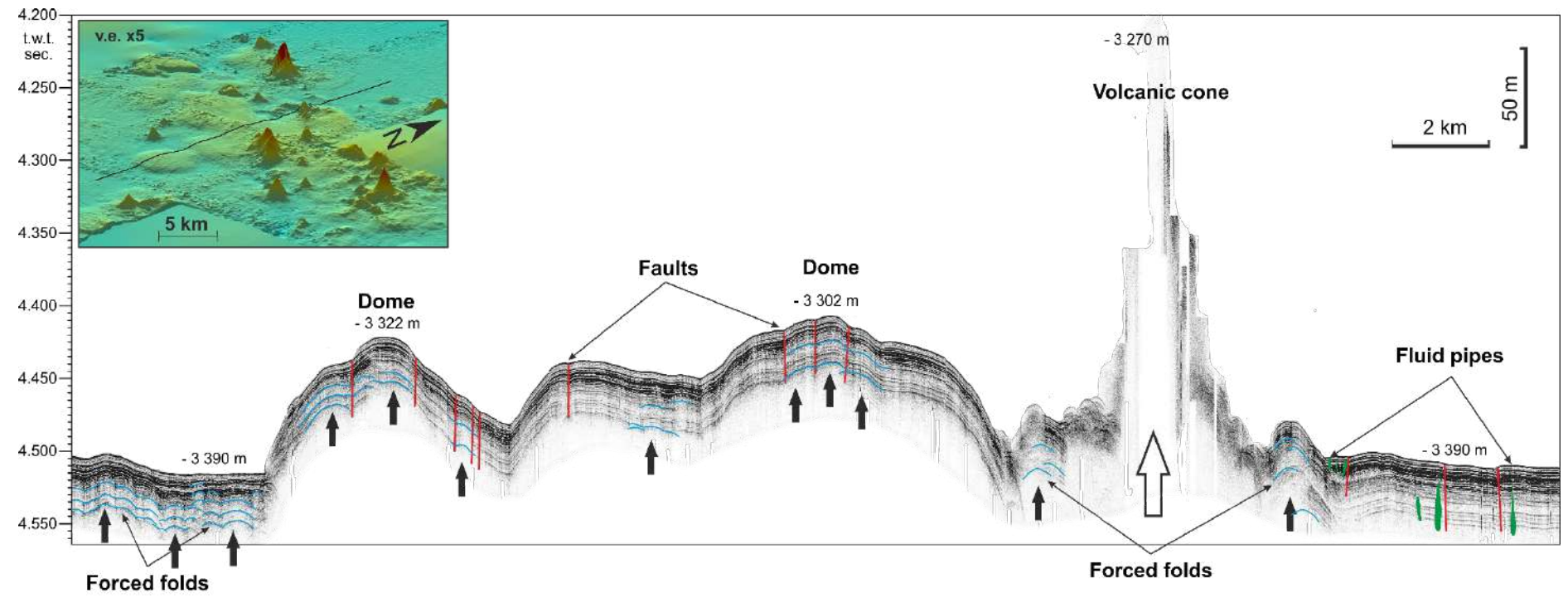
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v.e. x5

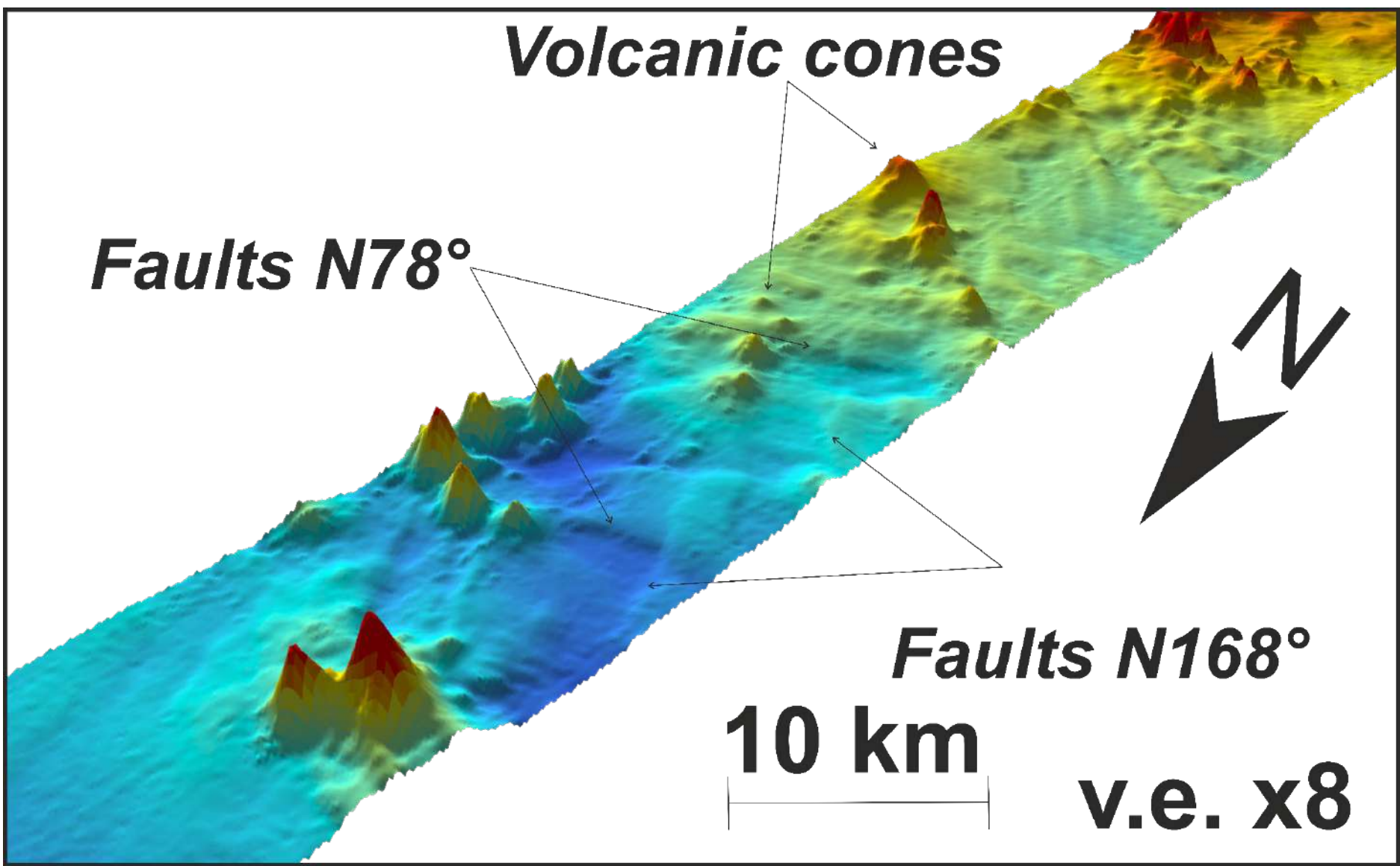


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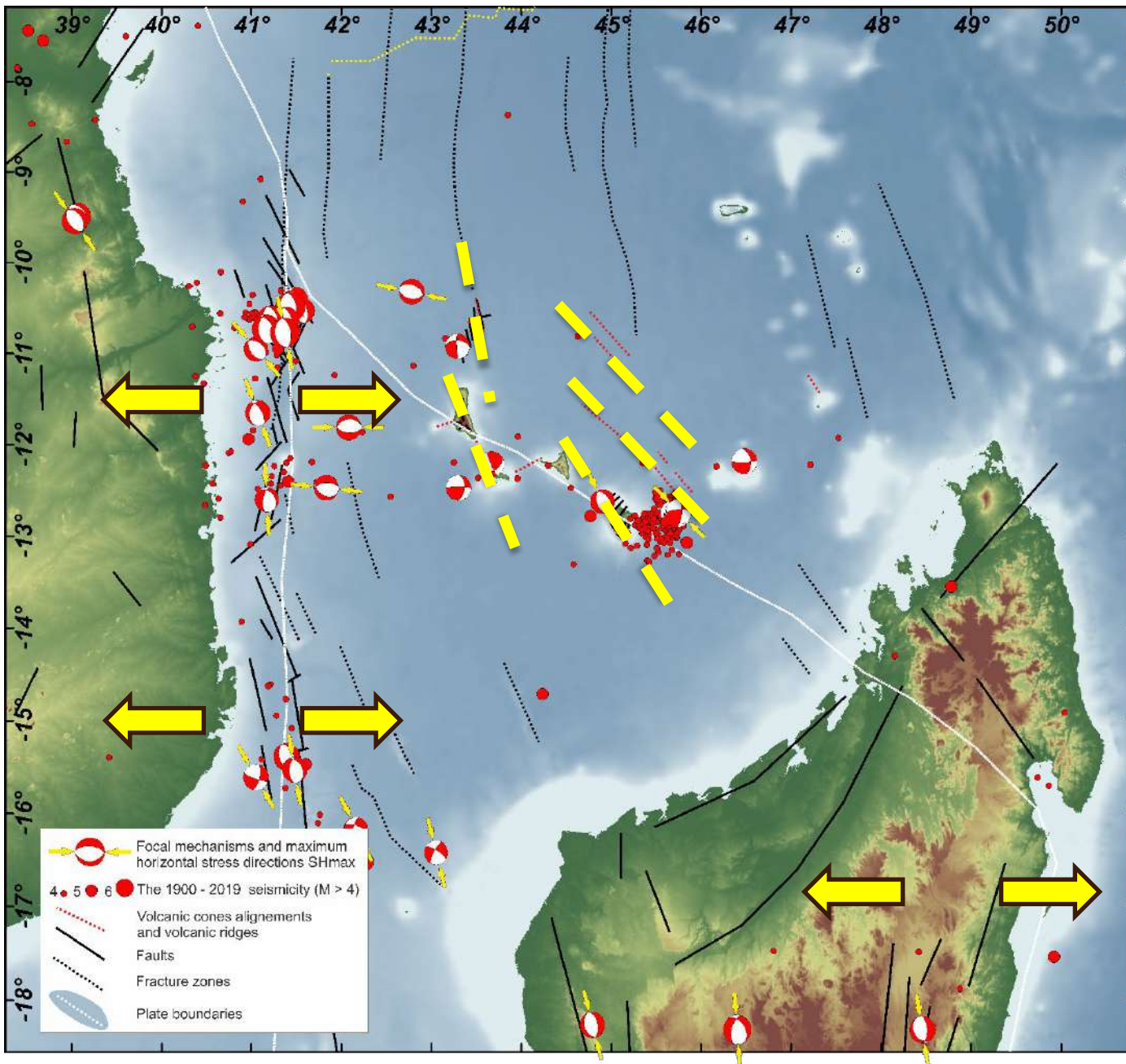


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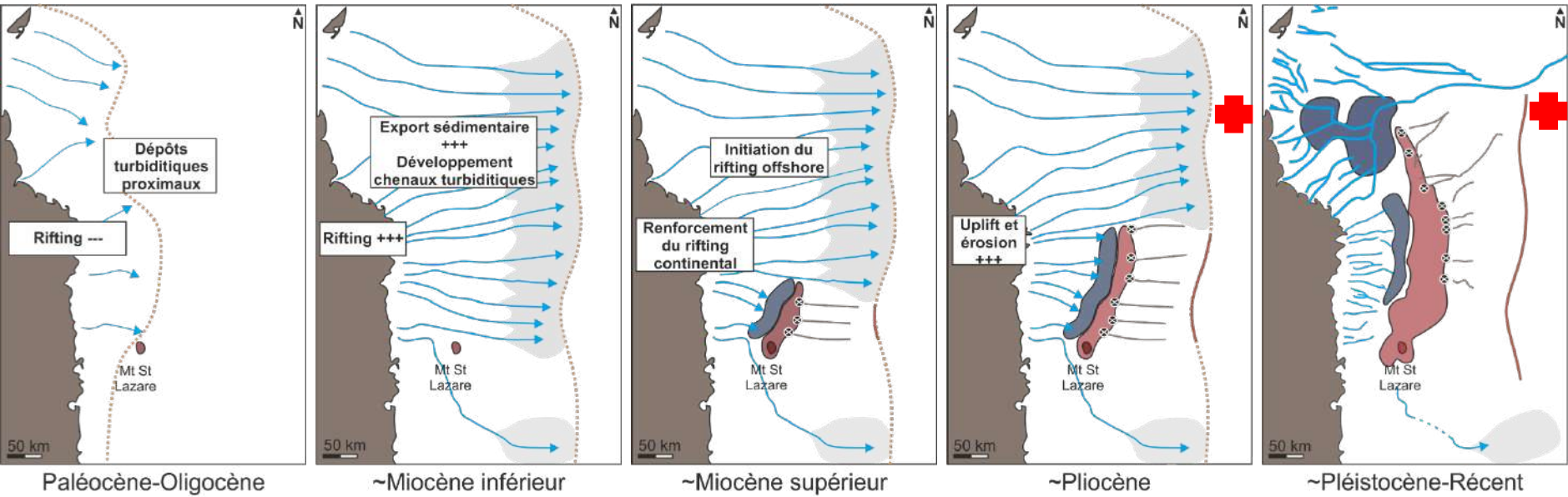




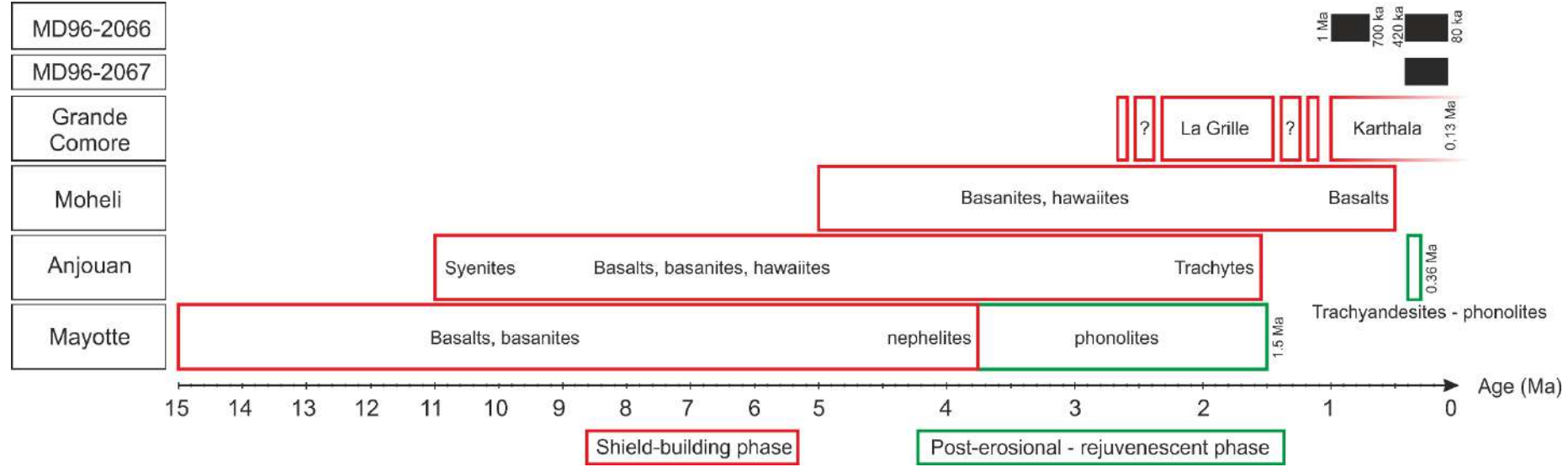
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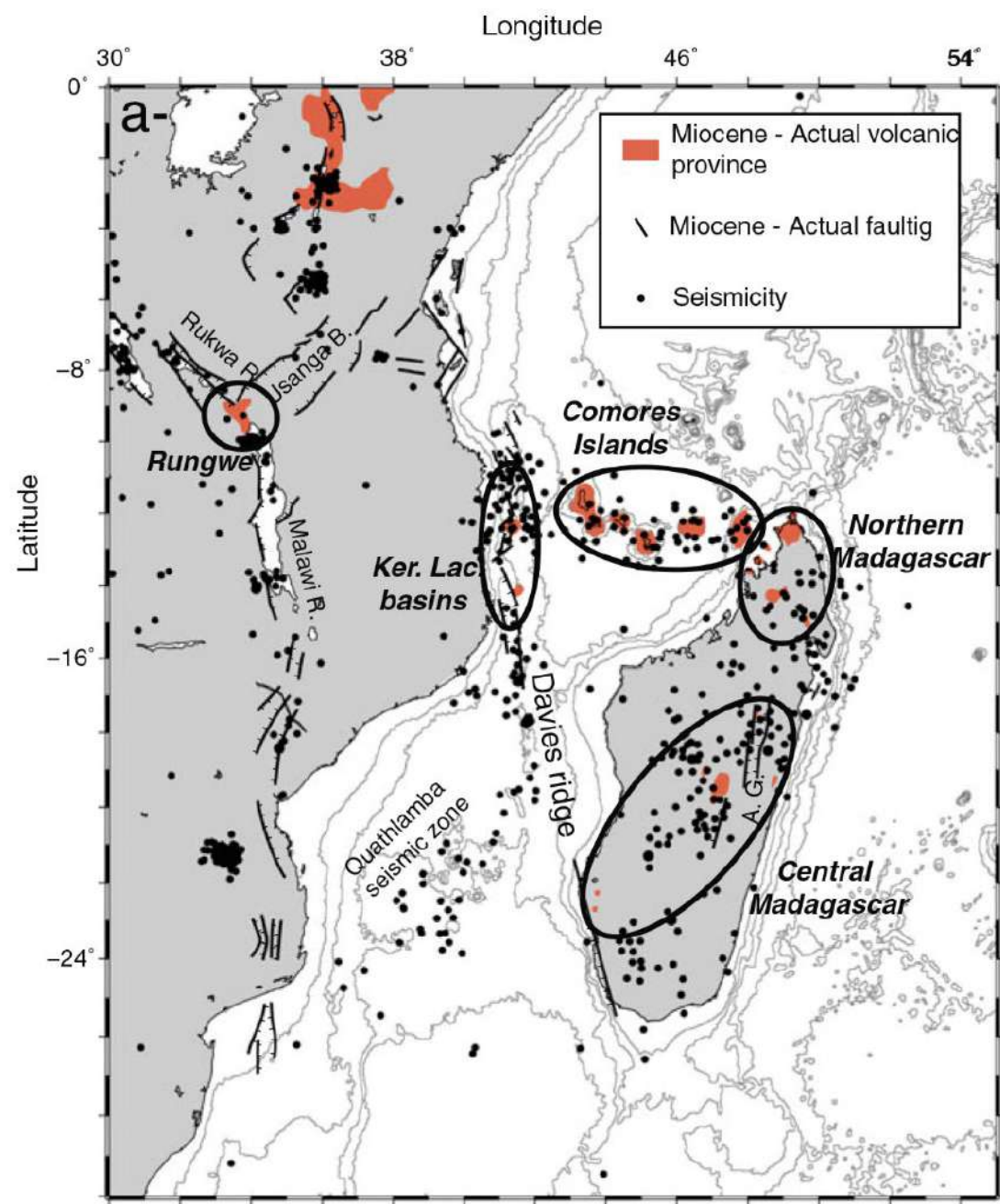






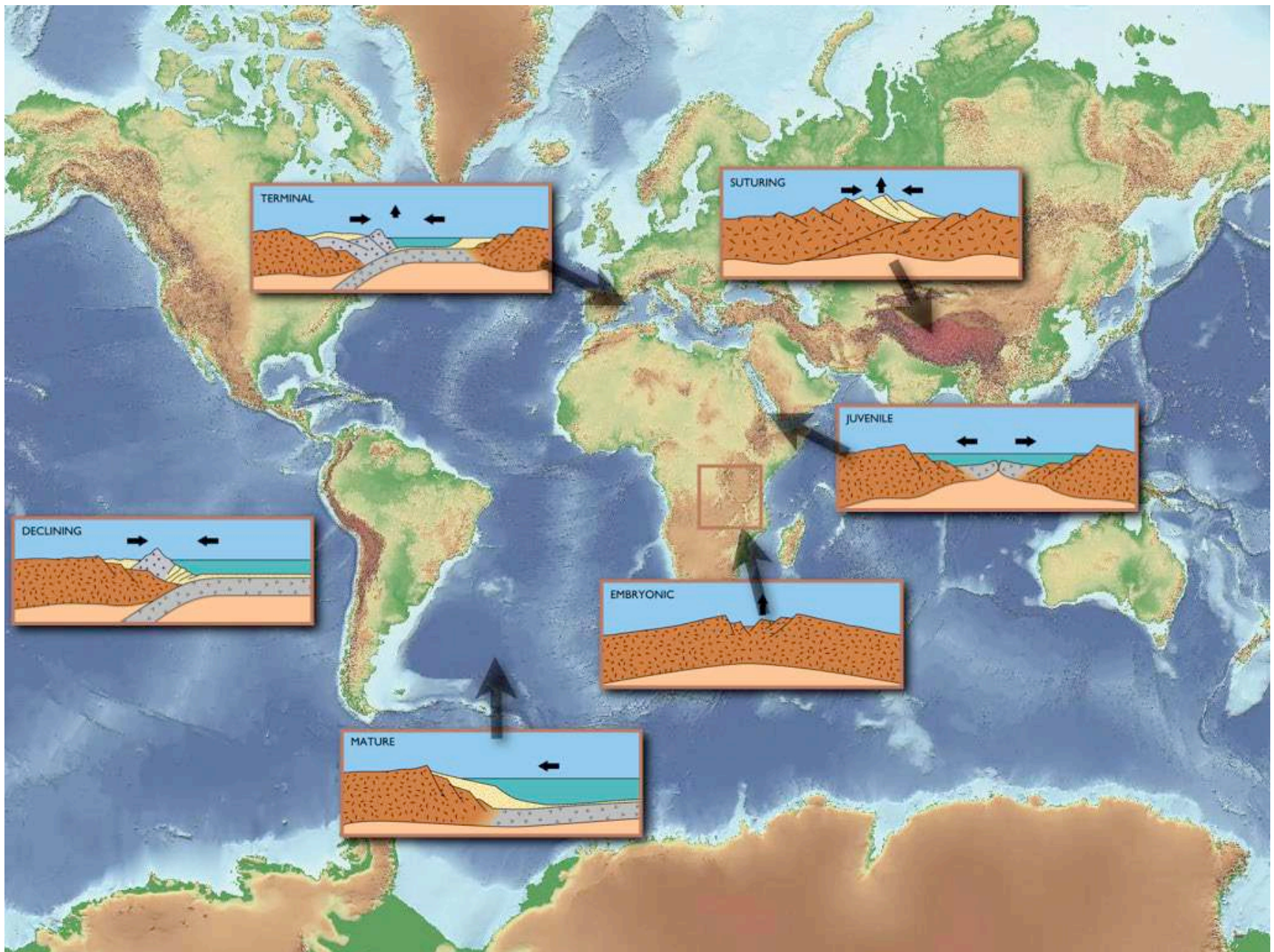
**Fournier 2016**





Bachelery, Patrick, Jean-François Lenat, Andrea Di Muro, et Laurent Michon, éd. Active Volcanoes of the Southwest Indian Ocean. Active Volcanoes of the World. Berlin, Heidelberg: Springer Berlin Heidelberg, 2016.





[http://commons.wikimedia.org/wiki/File:Wilson-stages\\_hg.png](http://commons.wikimedia.org/wiki/File:Wilson-stages_hg.png)