

# L'histoire des fleuves passés

Comment étudier un fleuve ancien pas ses dépôts Profonds ?

Sébastien Zaragosi  
Université de Bordeaux  
s.zaragosi@epoc.u-bordeaux1.fr  
<http://www.zaragosi.fr>

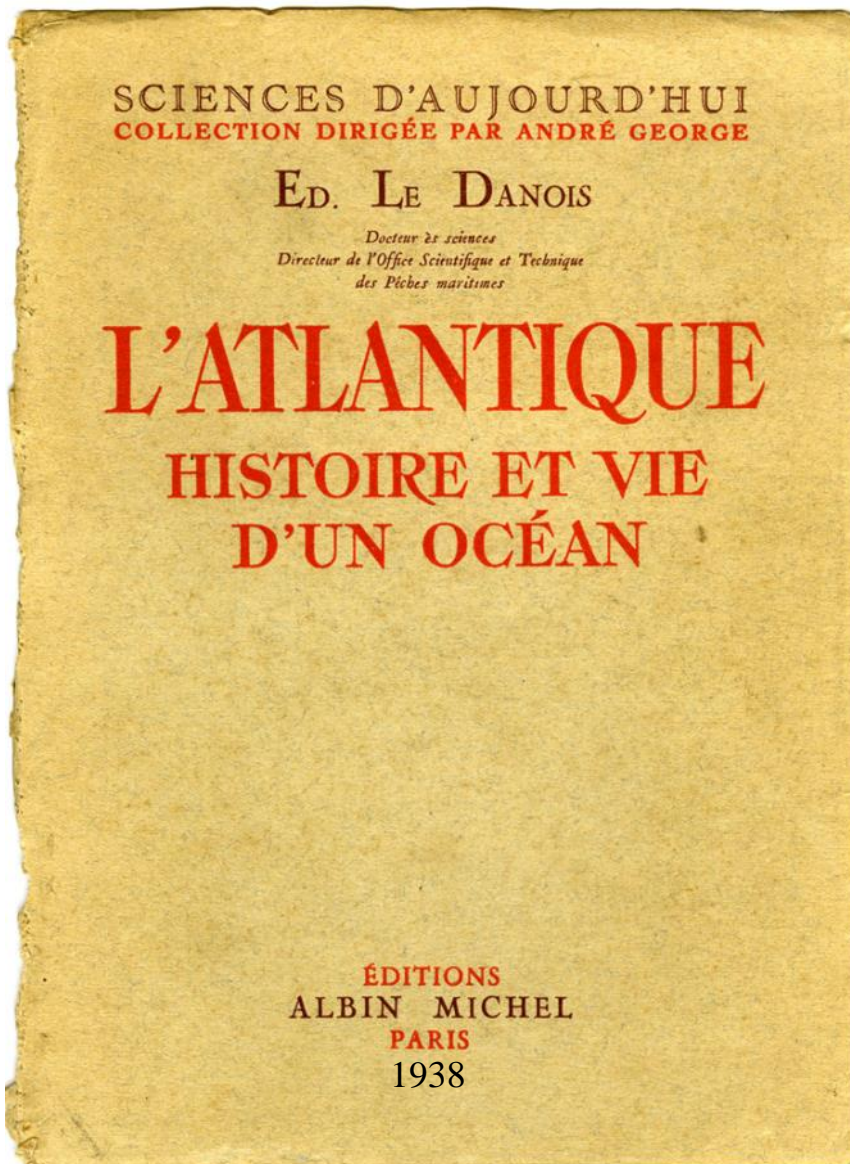
université  
de **BORDEAUX**



Extrait de la carte de France de Cassini 1815

# L'histoire des fleuves passés

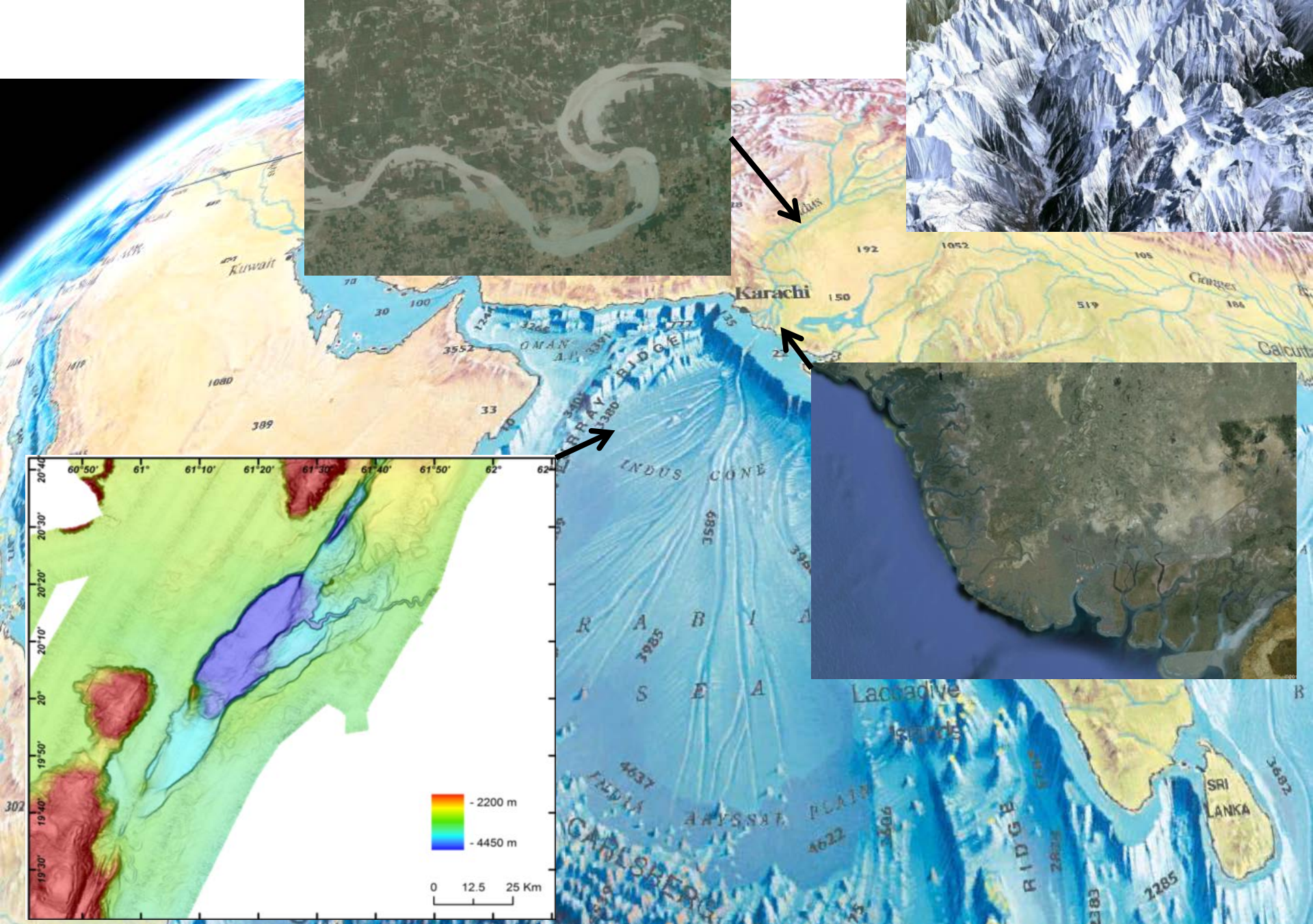
Comment étudier un fleuve ancien pas ses dépôts Profonds ?

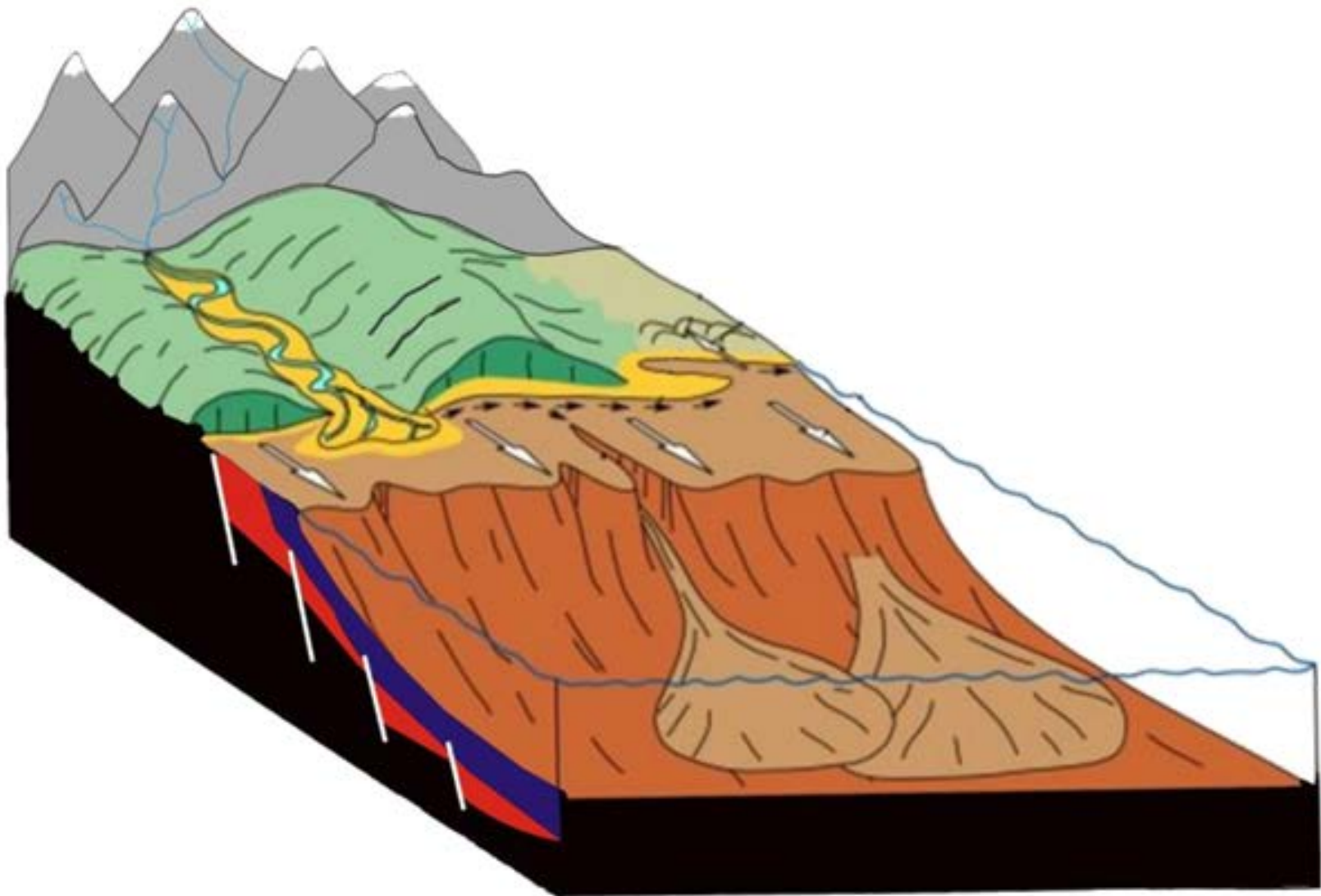


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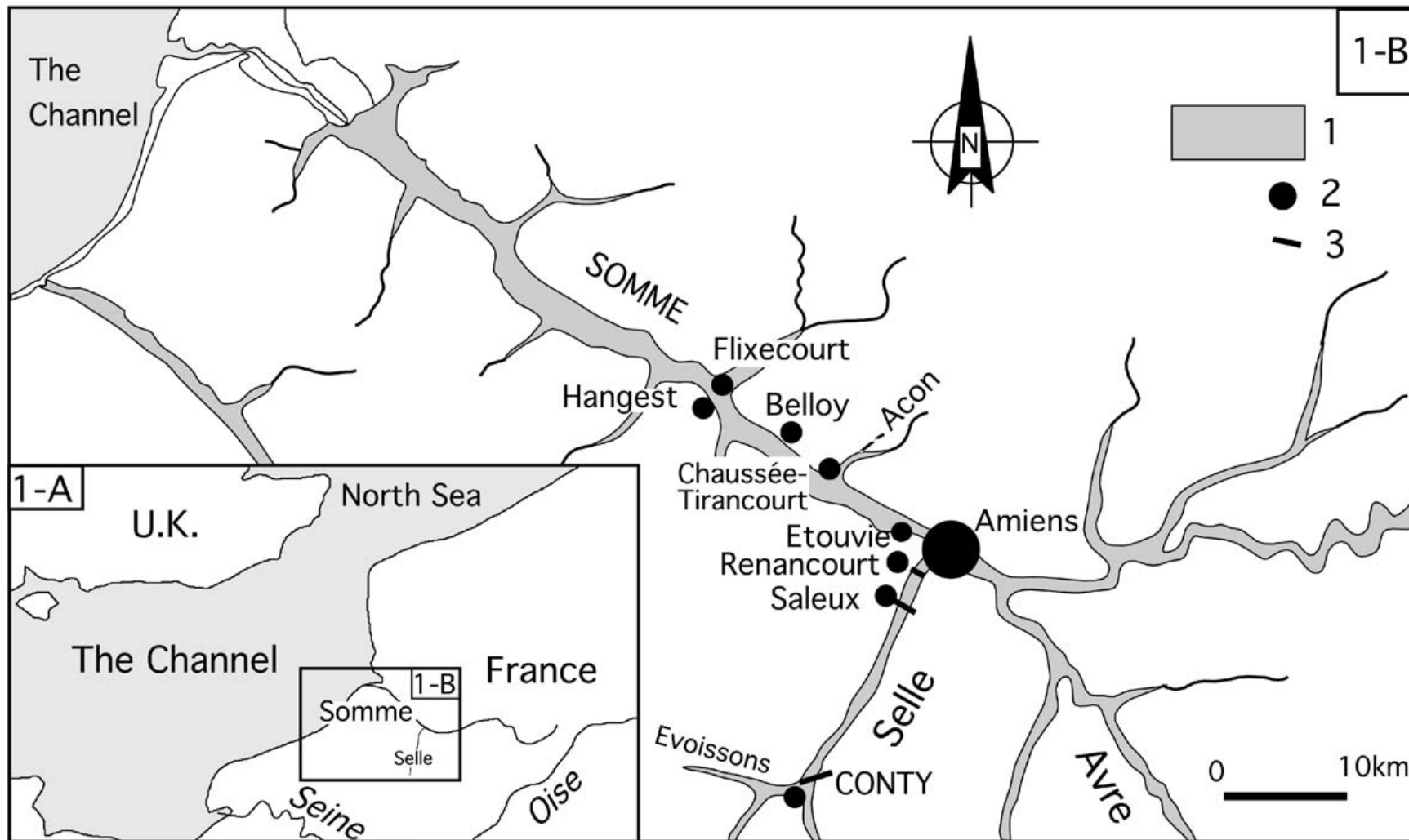
Comment étudier un fleuve ancien pas ses dépôts Profonds ?

- ➔ Samuel Toucanne 2008 Reconstruction des transferts sédimentaires en provenance du système glaciaire de Mer d'Irlande et de Paléo-fleuve Manche au cours des derniers cycles climatiques.
- ➔ <http://www.epoc.u-bordeaux.fr/indiv/Zaragosi/publications.html>
- ➔ <http://www.zaragosi.fr>

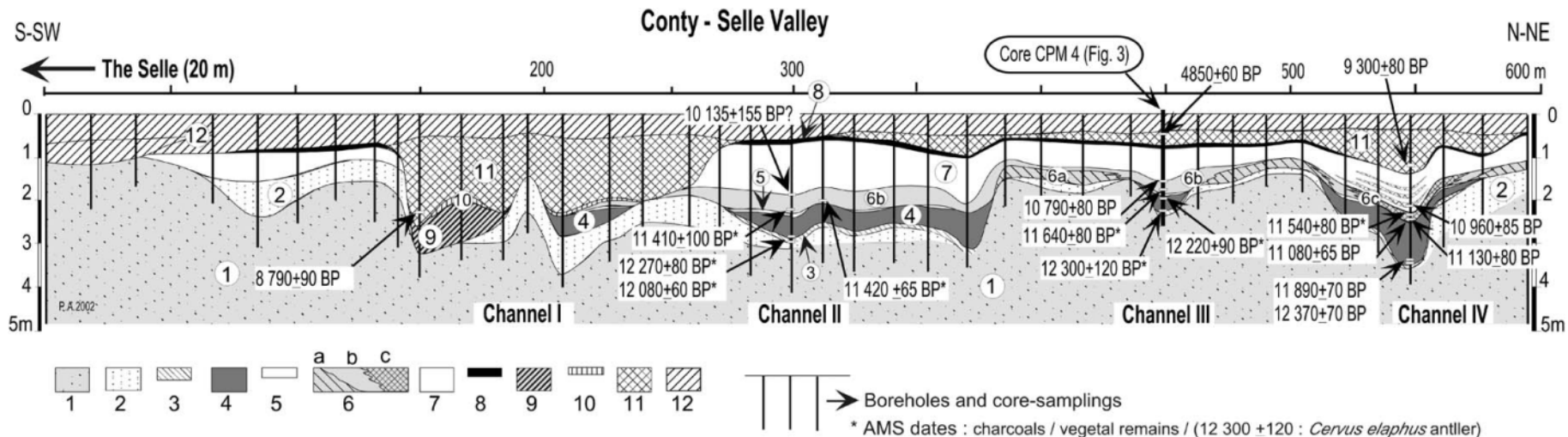








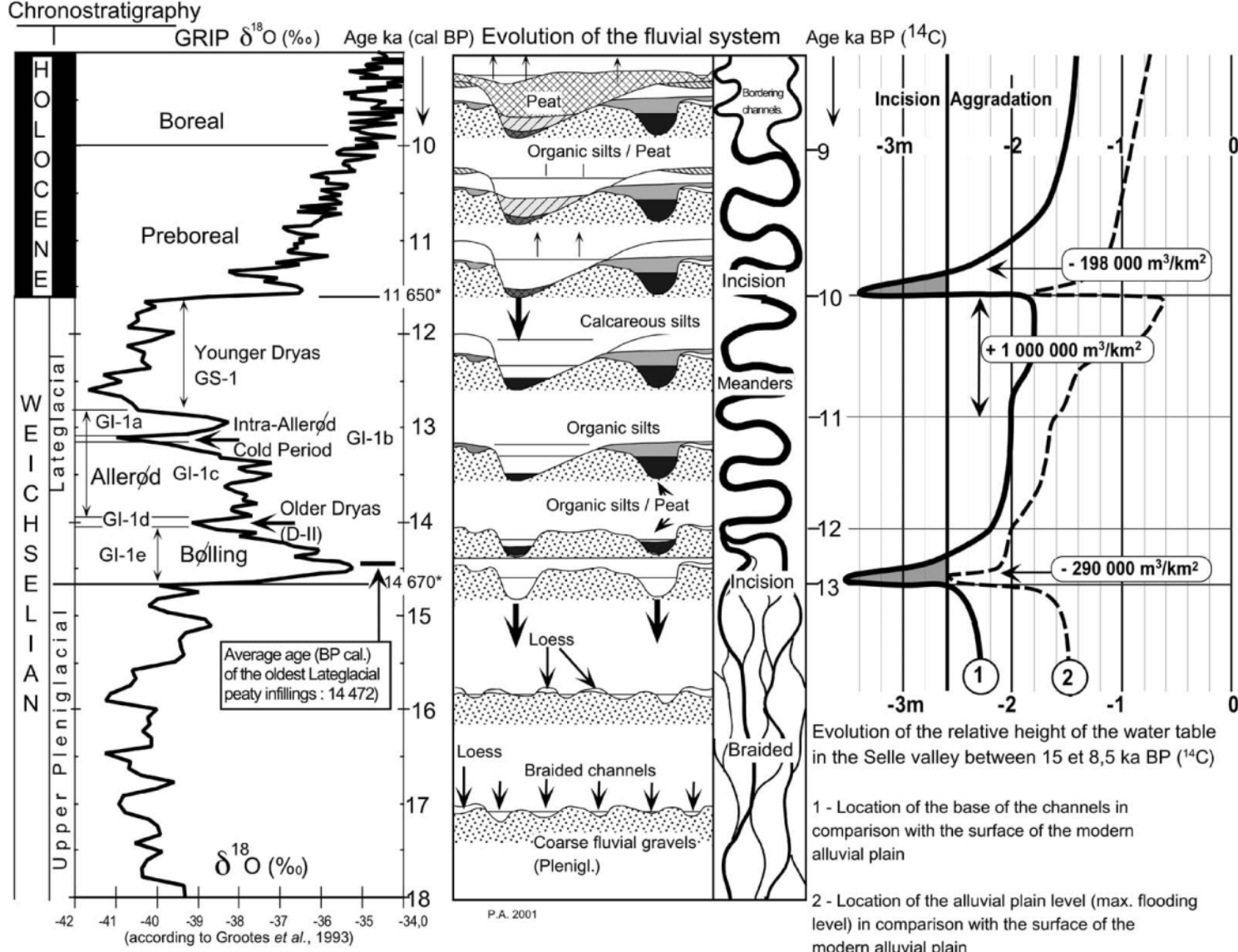
Antoine, P. et al. 2003



**Antoine, P. et al. 2003**

Detailed cross-section through the Selle valley at Conty (modified after Antoine, 1997b).

- (1) valley-floor gravel
- (2) Loessic silt
- (3) slightly organic silt
- (4) "reddish peat" with numerous plant remains (wood, bark, seeds) and molluscs
- (5) thin horizon of white calcareous silt
- (6a) calcareous organic silts with chalk granules, (6b) grey organic silts with organic horizons and final palaeolithic artefacts, (6c) lateral peaty facies of (6b)
- (7) homogeneous and light-grey silt with abundant terrestrial molluscs and organic horizons at the base containing aquatic molluscs
- (8) clayey grey-black organic silt
- (9) flint gravel with organic matrix and plant remains
- (10) granular calcareous tufa (lens at the bottom of channel I)
- (11) black peat
- (12) complex of clayey silts with Gallo-Roman level covered by the current valley soil.



(INTIMATE Event stratigraphy according to Walker *et al.*, 1999).

\* Ages Cal. BP of the beginning of the Bølling and of the Holocene according to Stuiver *et al.*, 1995 ; Taylor *et al.*, 1997).

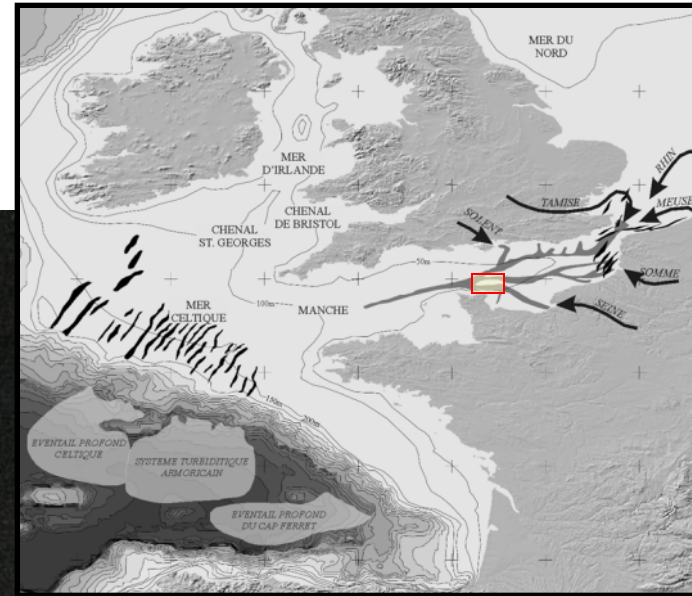
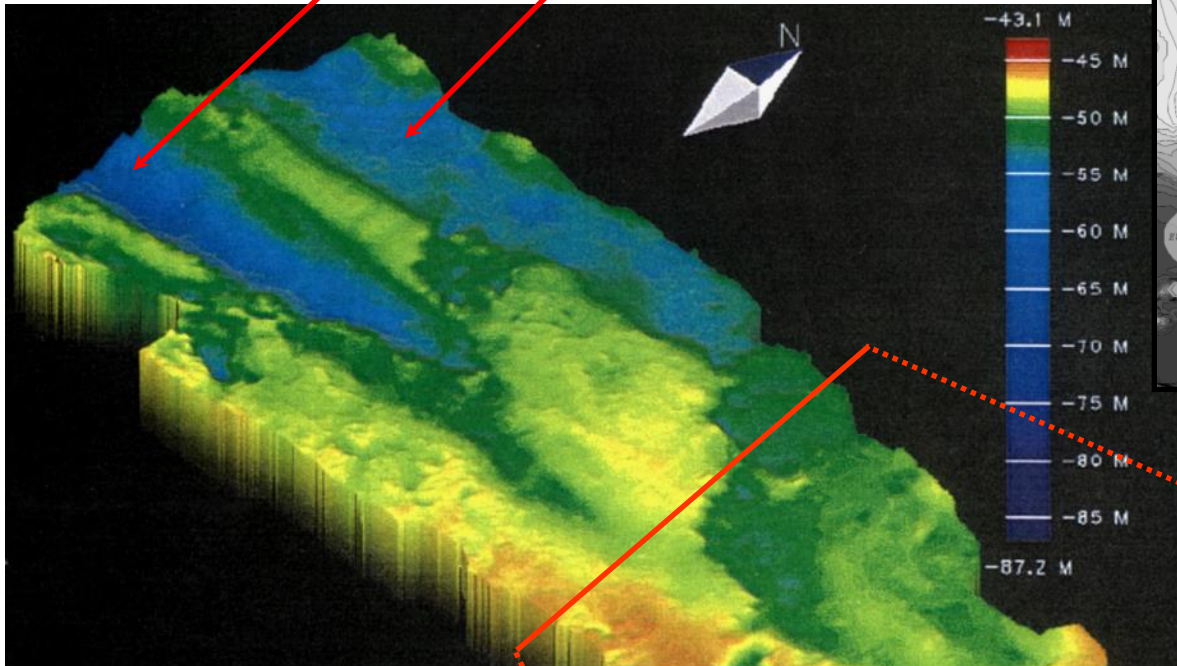
Antoine, P. et al. 2003

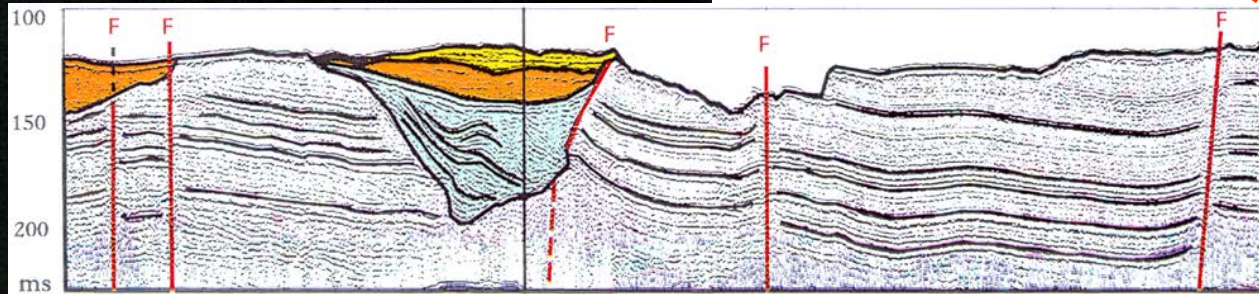
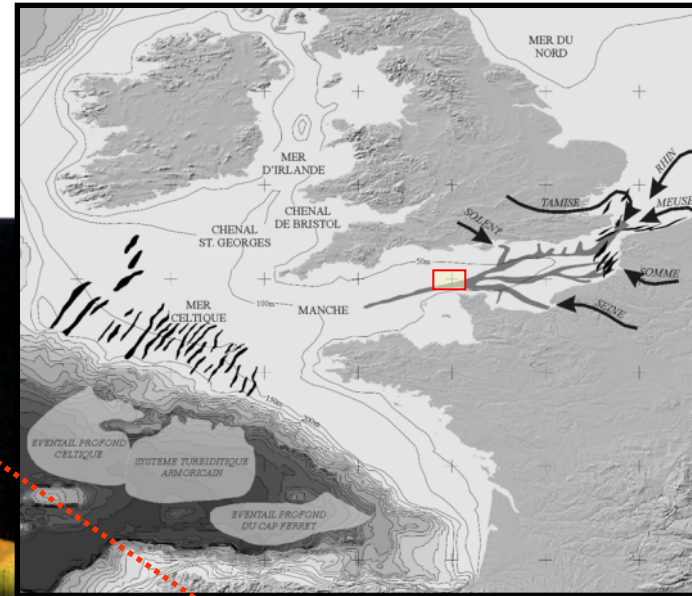
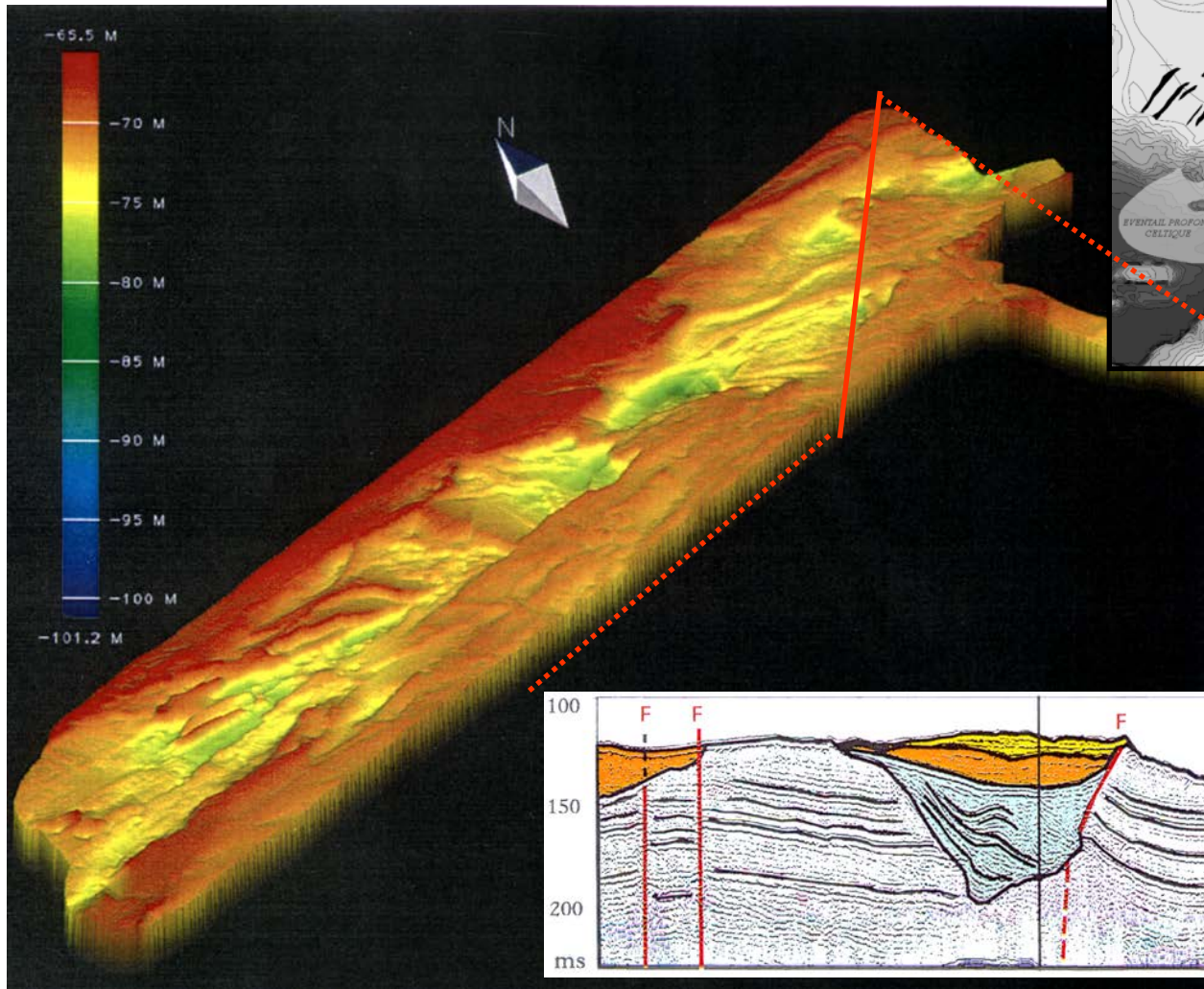
Modification of environments in the Selle valley during the Lateglacial, correlation with the  $\delta^{18}\text{O}$  signal at GISP II, and preliminary assessment of sedimentary budgets for the Upper Selle area (modified after Antoine *et al.*, 2000). (The sedimentary budgets are calculated on the base of the average thickness of the main units in the reference section at Conty extrapolated to a 1km long area of valley. In addition, determination of the volume of the Younger Dryas deposits and of the eroded sediments at the beginning of the Preboreal is reinforced by data from the Saleux and Renancourt cross sections and by other intermediate observation points).

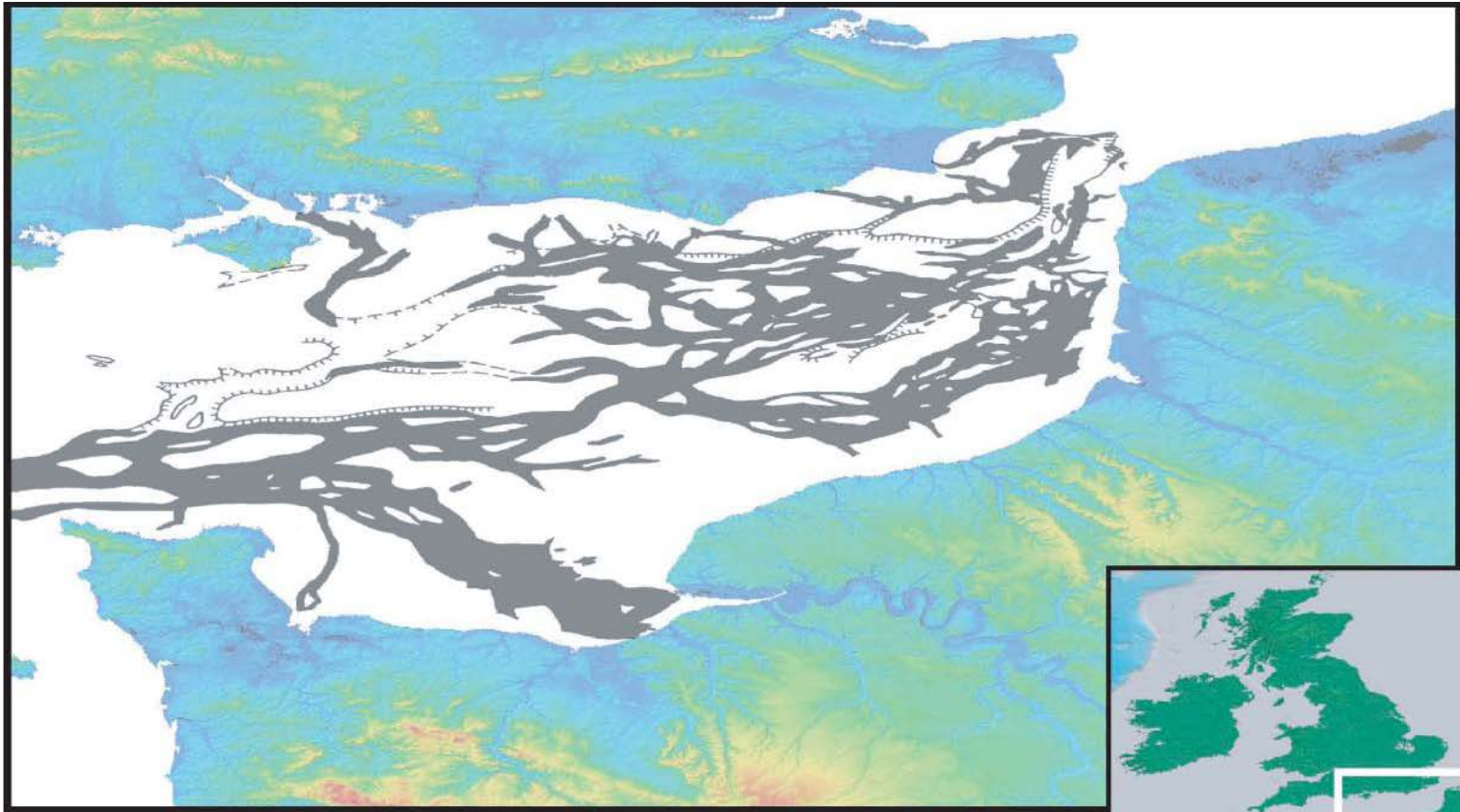


PaléoSomme

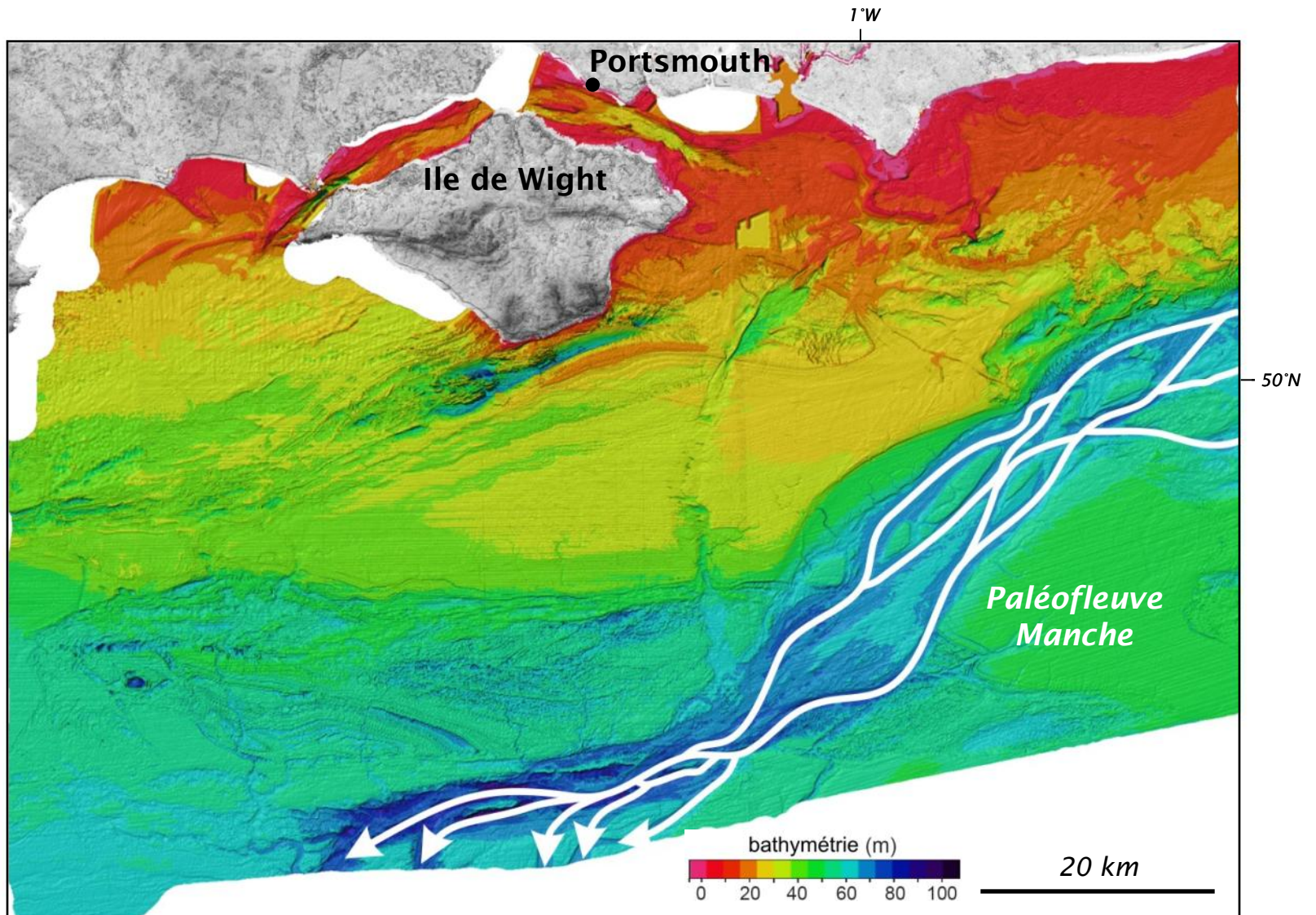
PaléoSeine



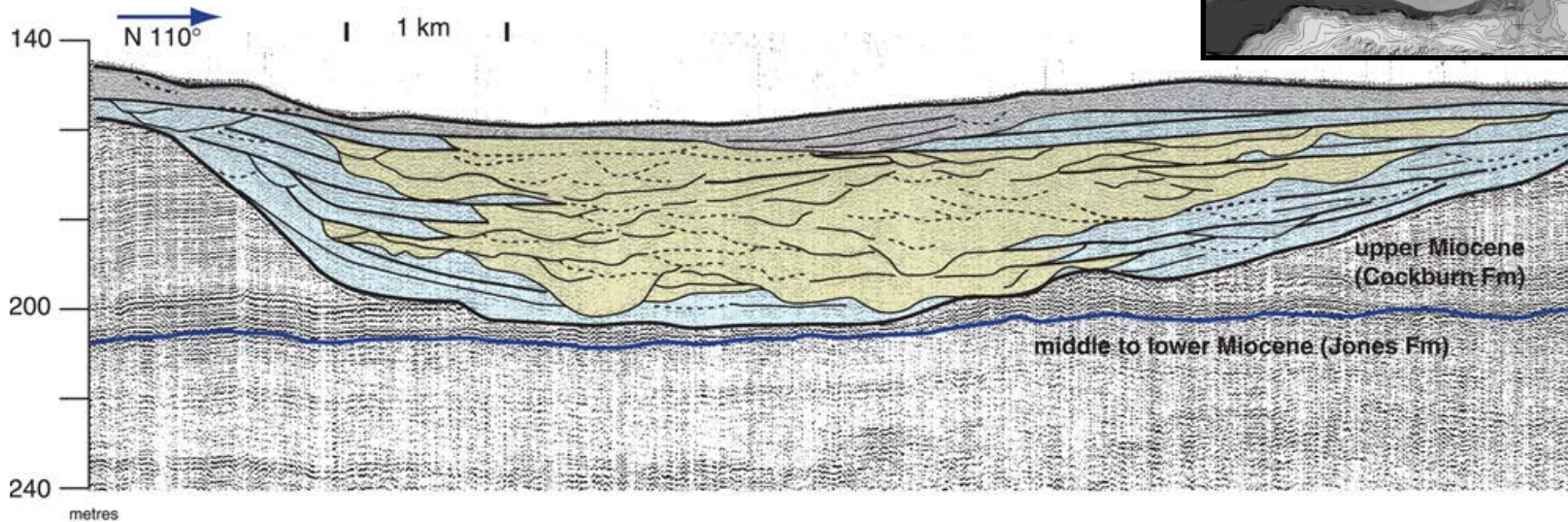




Gupta et al., Nature, 2007



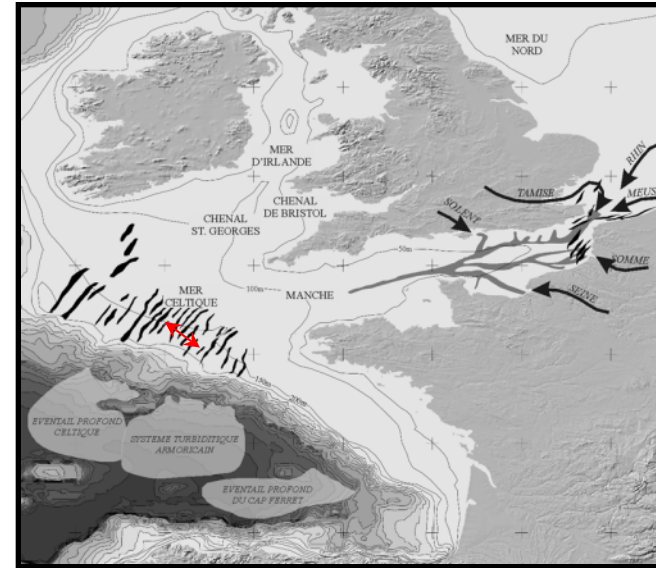
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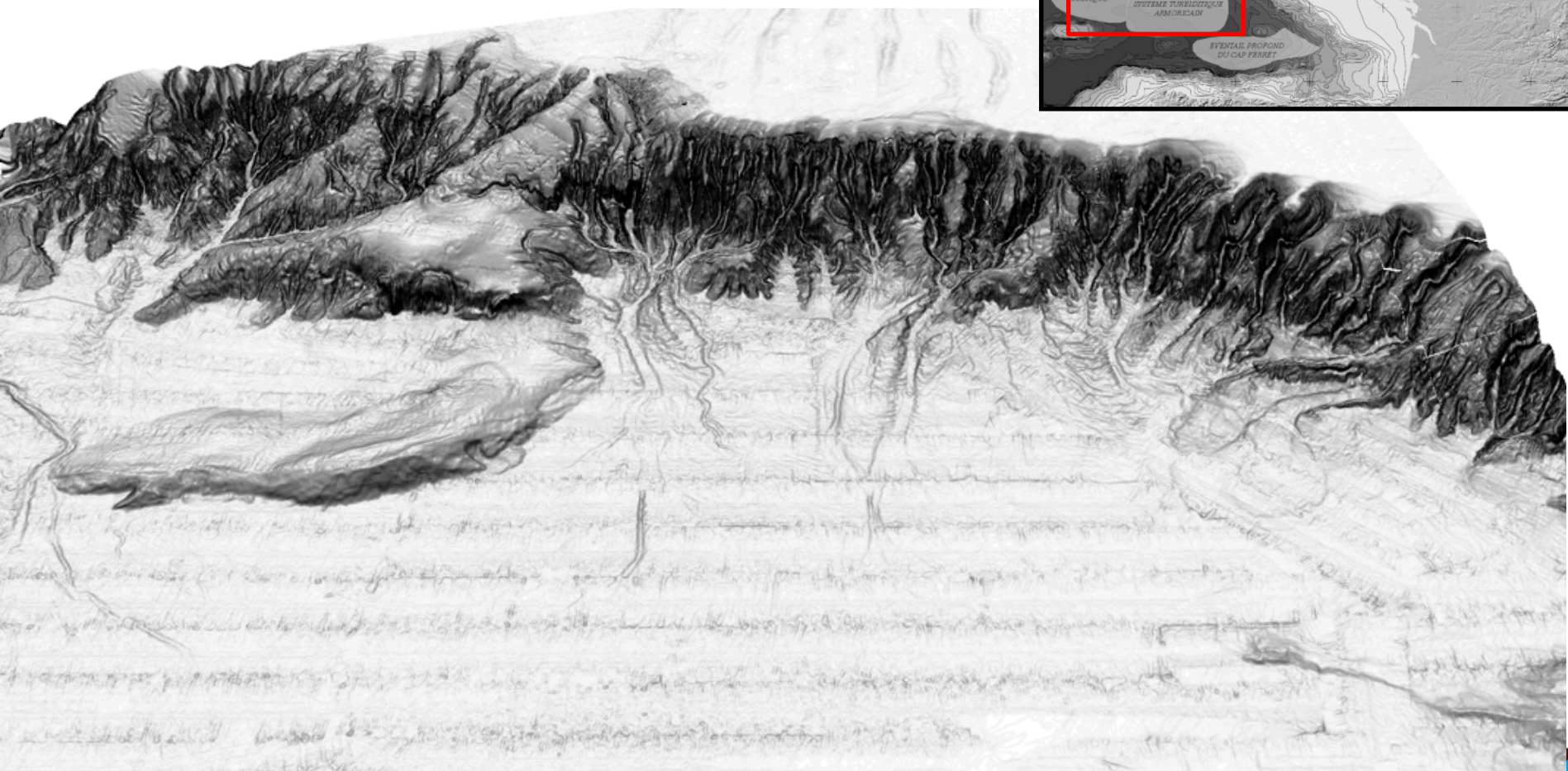


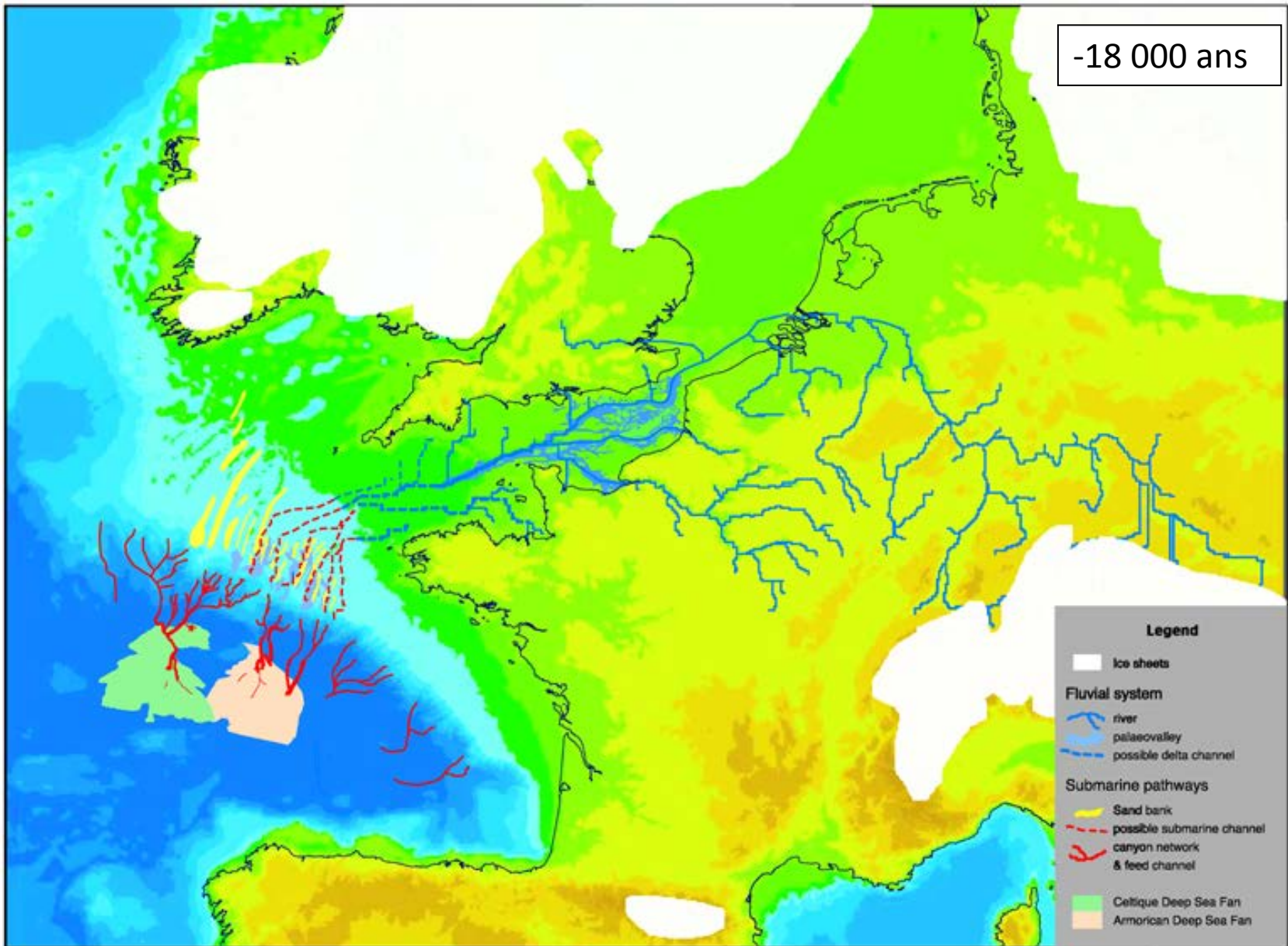
Profile B96-20

- main unit boundary (ravinement surface ?)
- acoustic reflector (incision, lag)
- - - acoustic reflector (unclear)

- valley cut and fill dominated facies (fluvial / estuarine channels)
- valley aggrading dominated facies (bay / overbank deposits)
- shelf units (offshore sandbanks and dunes)







# L'histoire des fleuves passés

Comment étudier un fleuve ancien pas ses dépôts Profonds ?

## L'Histoire du Fleuve Manche

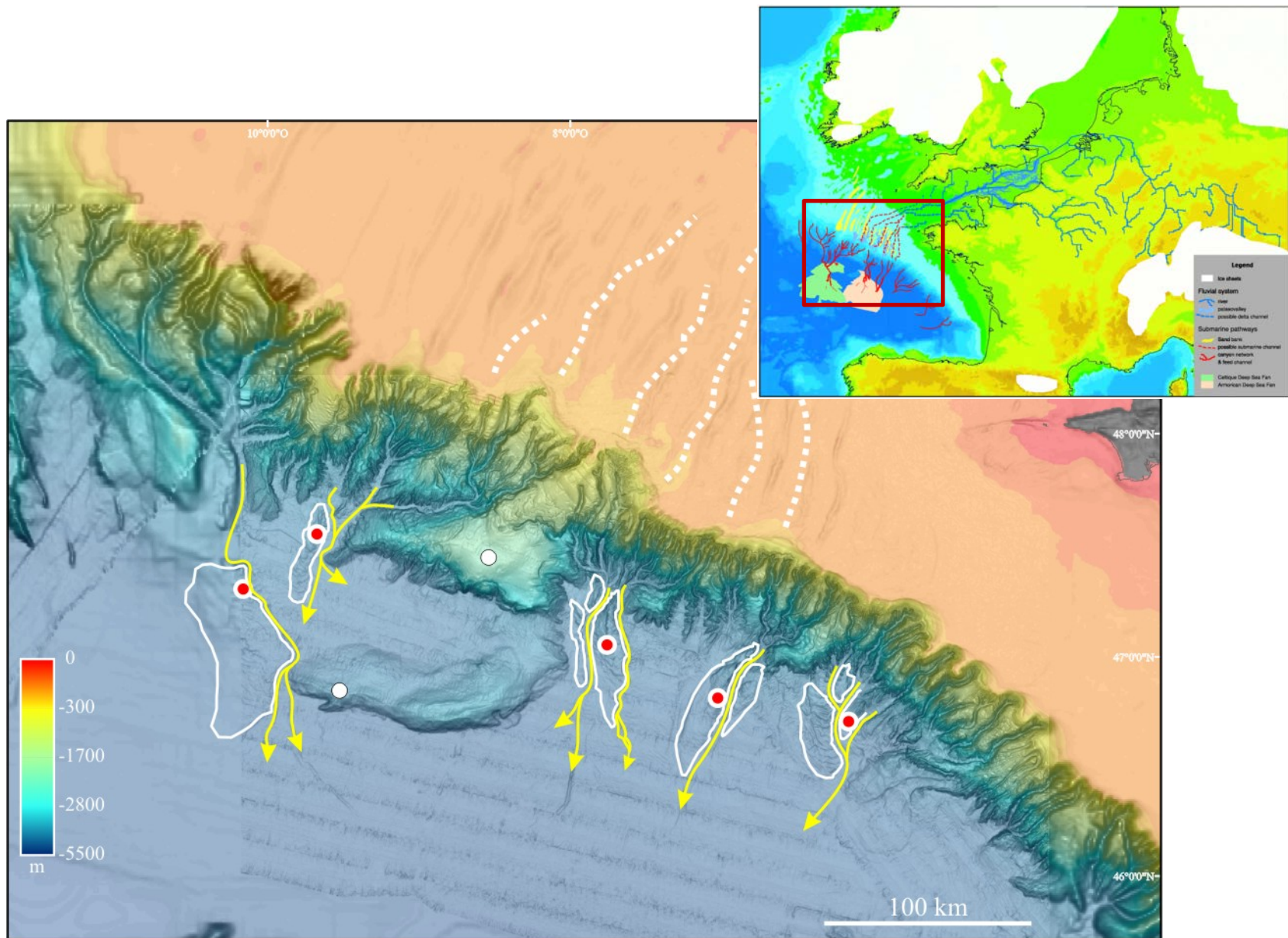
- ➔ Quelle a été sa période d'activité ?
- ➔ Quel était son régime hydrologique ?
- ➔ Peux-t-on estimer son débit solide ?
- ➔ Quelle a été l'extension de son bassin versant ?

# L'histoire des fleuves passés

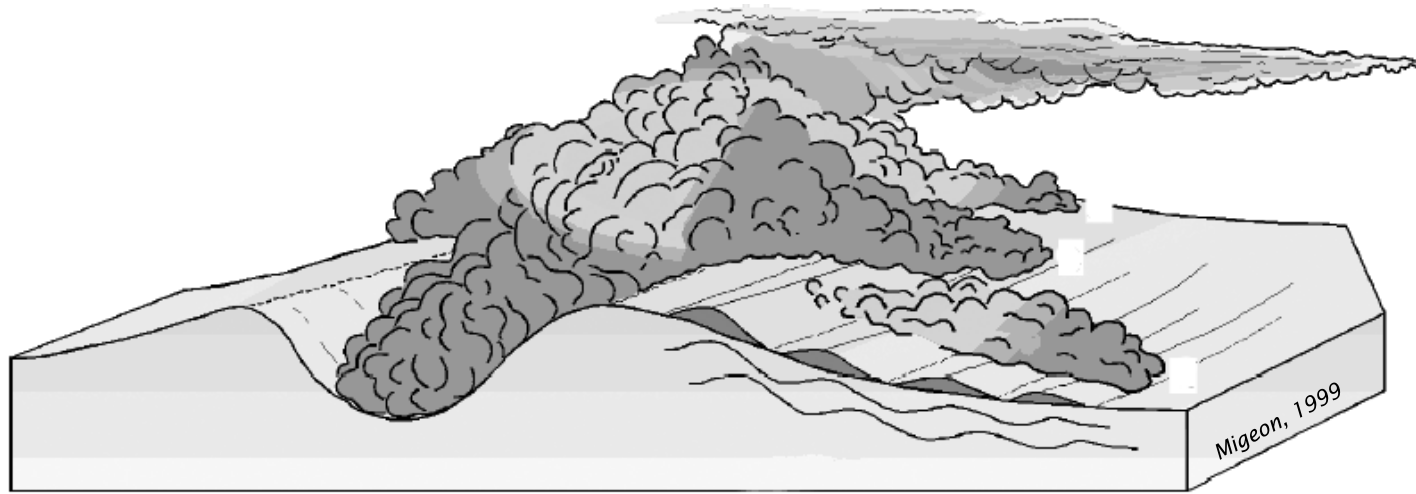
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## L'Histoire du Fleuve Manche

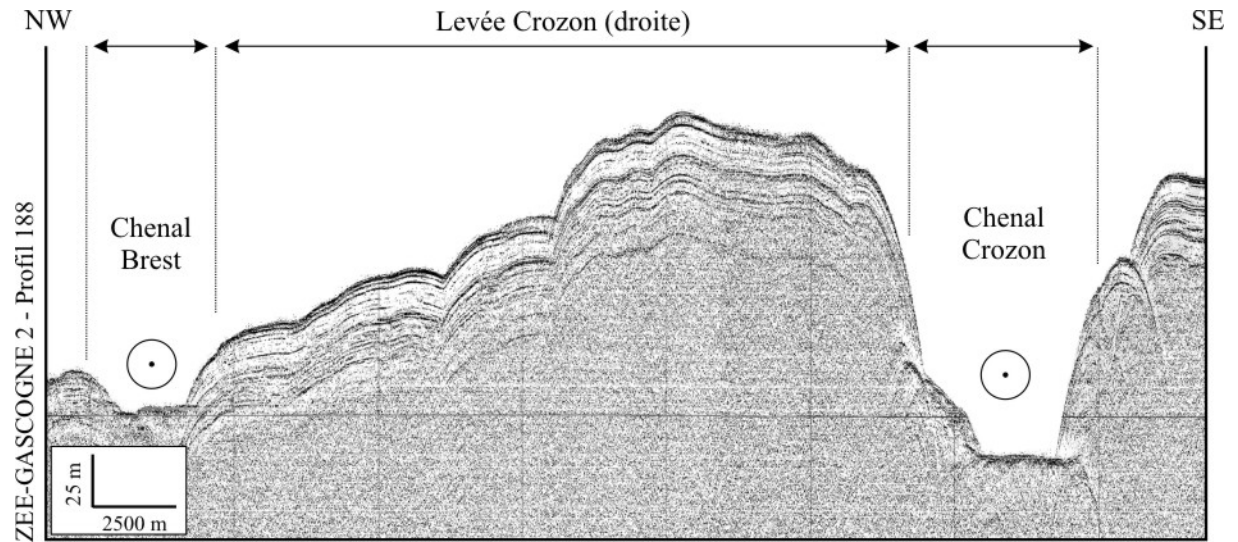
- ➔ **Quelle a été sa période d'activité ?**
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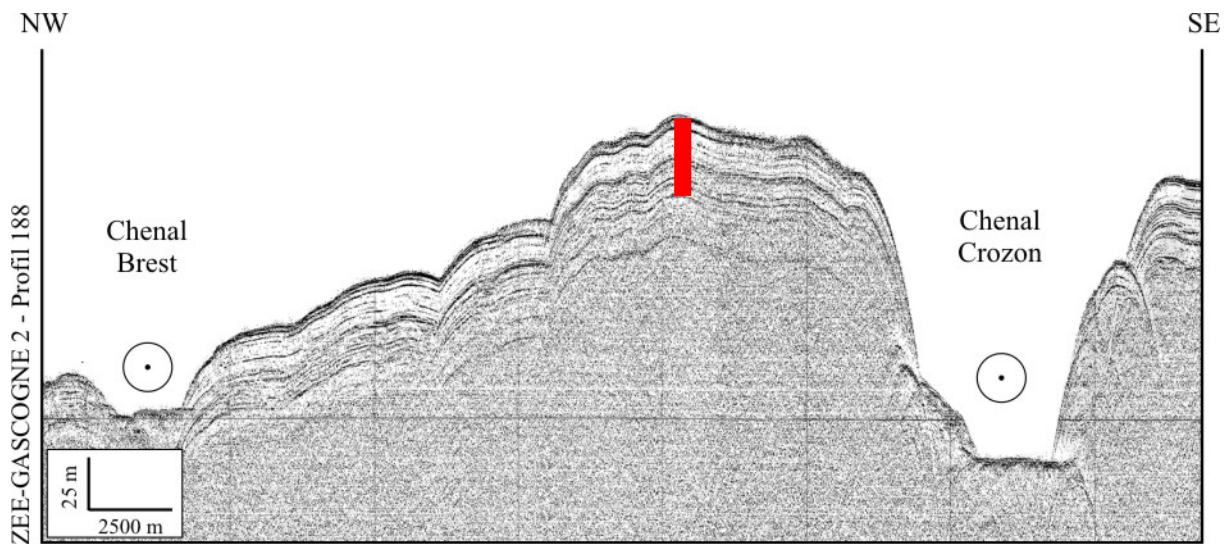
Taux de sédimentation forts (m/ka)



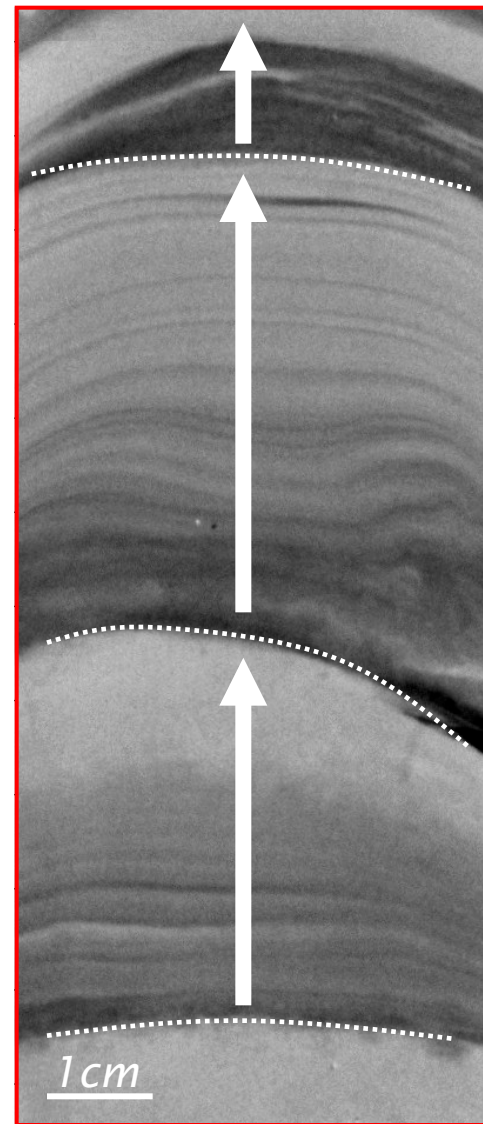
Construction des levées turbiditiques par débordement de nuages turbides



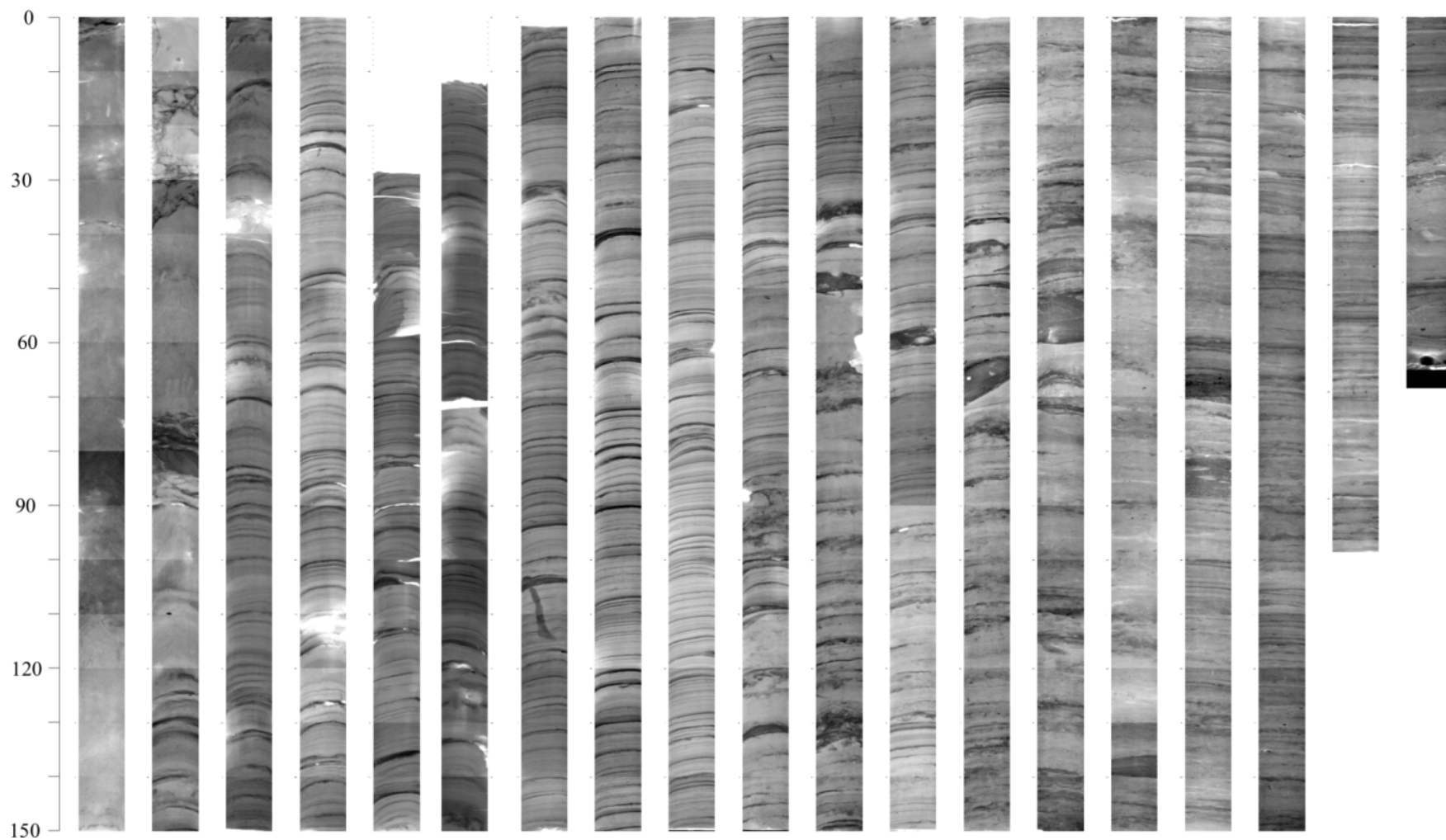
Structure interne de la levée turbiditique de Crozon (3,5 kHz)



Structure interne de la levée turbiditique de Crozon (3,5 kHz)

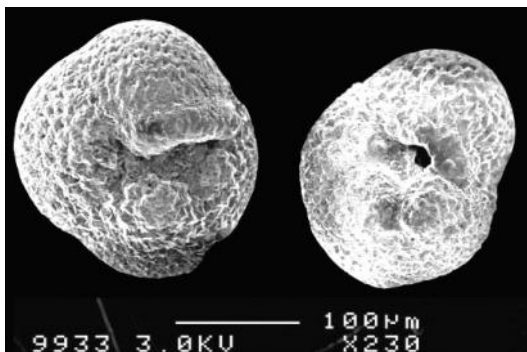


# Carotte MD03-2688 (35 mètres – 732 dépôts turbiditiques / 30.000 ans)

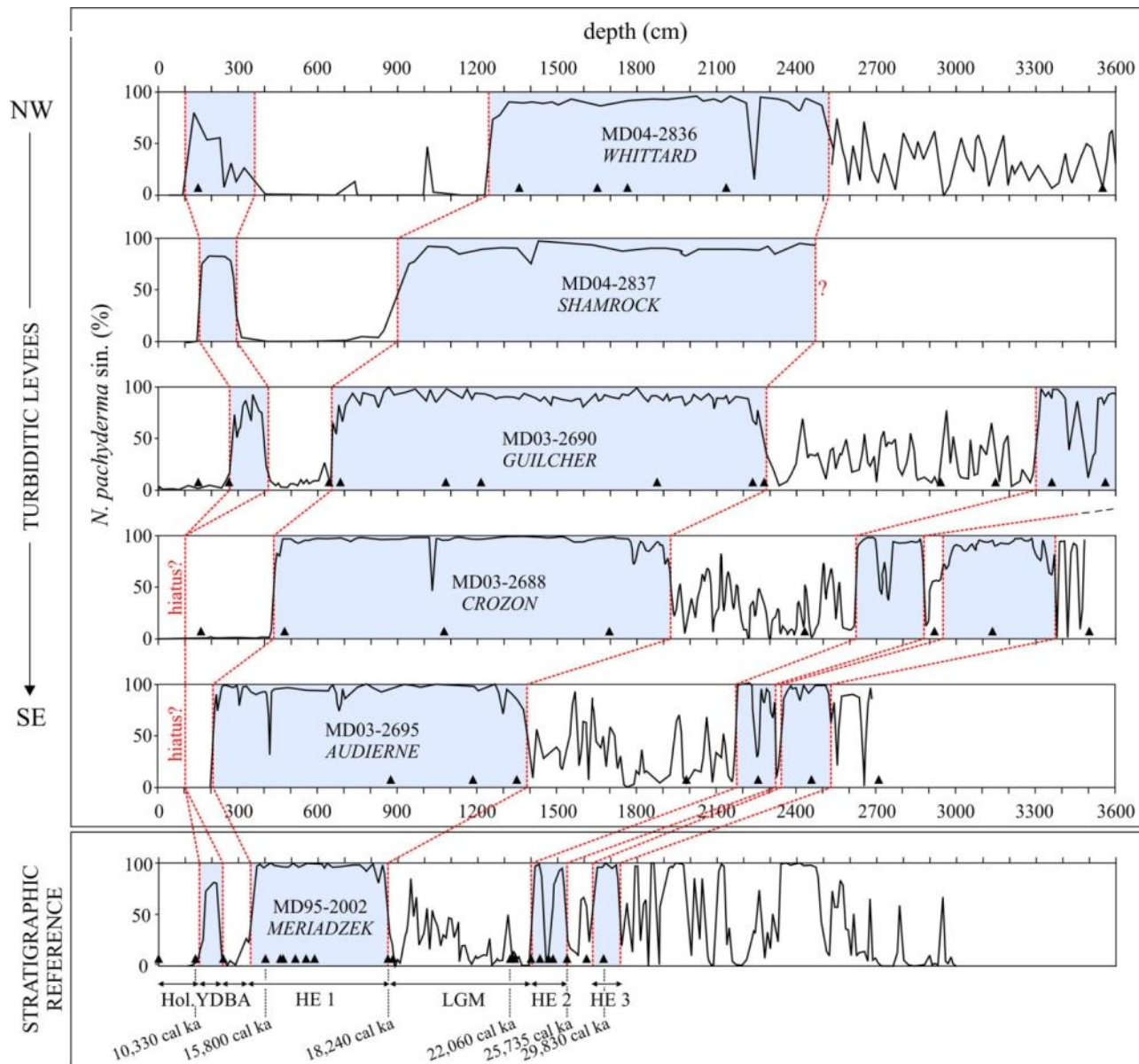


# Stratigraphie

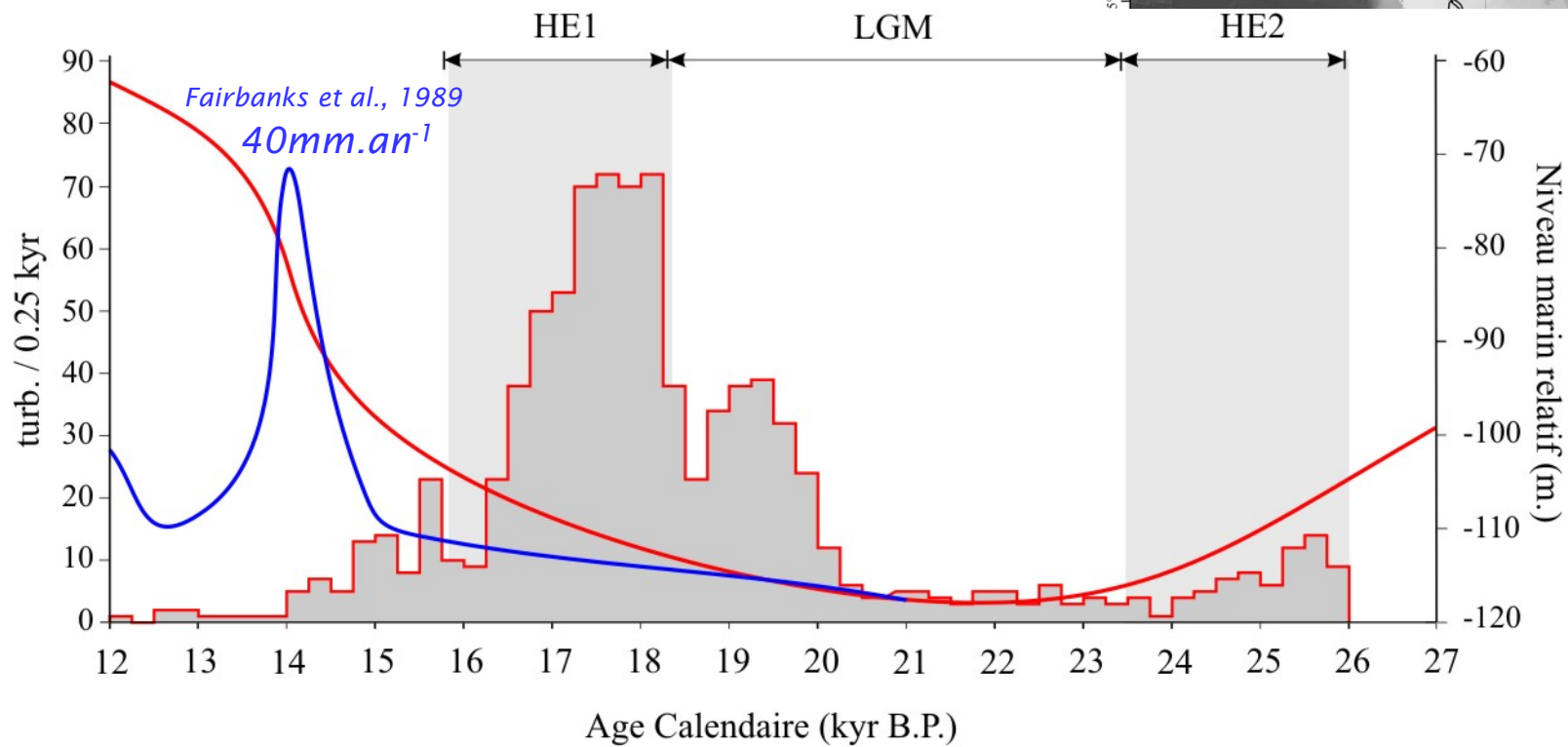
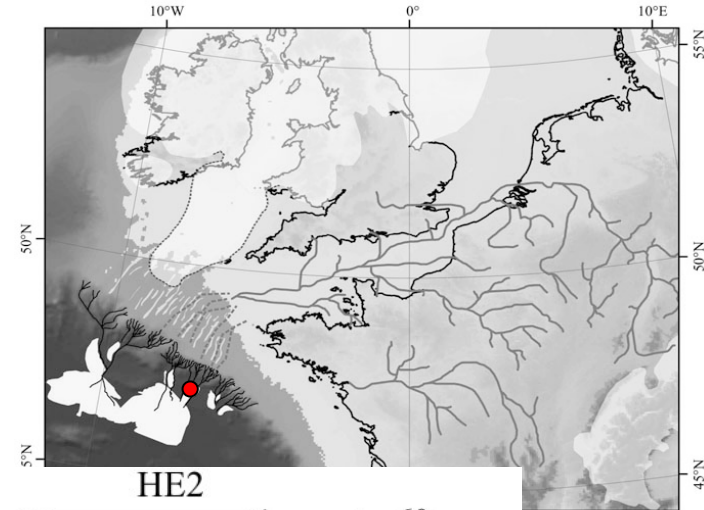
- ➔ Isotopes de l'oxygène (foraminifères benthiques)
- ➔ Datations  $^{14}C$
- ➔ Biostratigraphique



*Neogloboquadrina pachyderma* (s.)

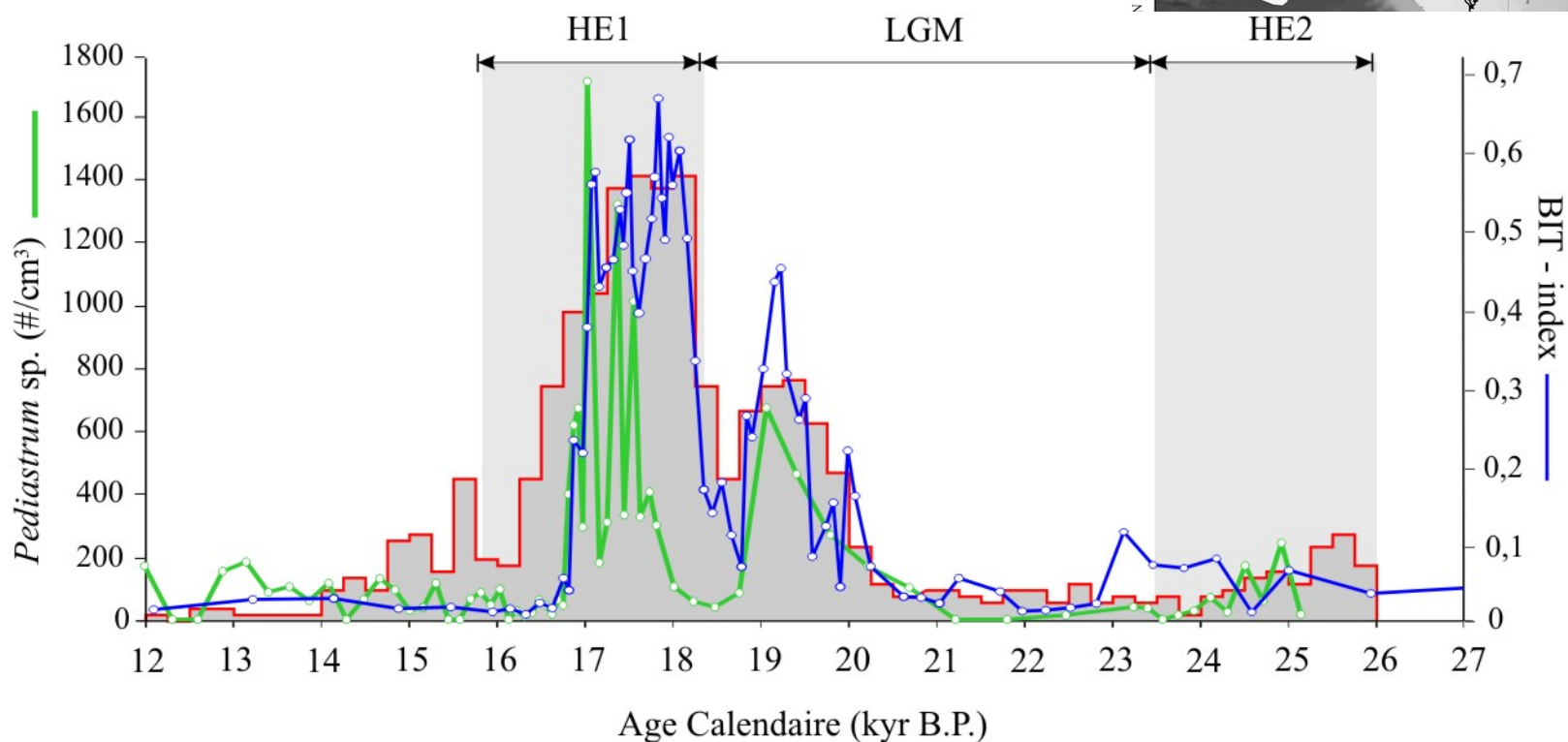
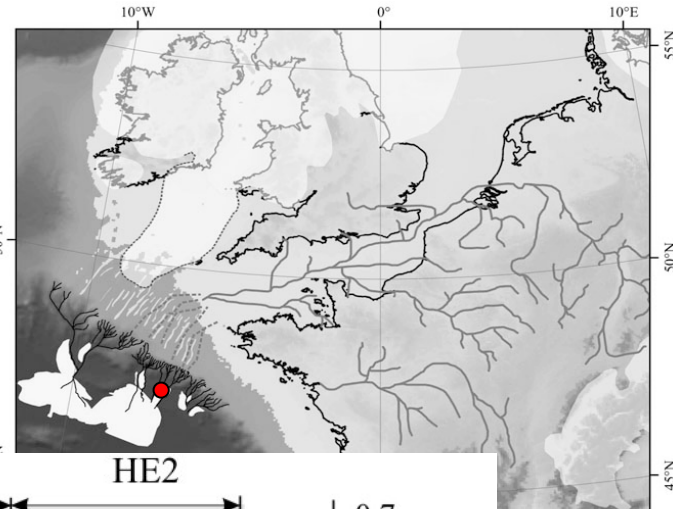


# Activité turbiditique – Système Armoricaïn



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Activité turbiditique liée aux flux d'eau douce  
Alimentation des systèmes turbiditiques  
contrôlée par le Fleuve Manche.

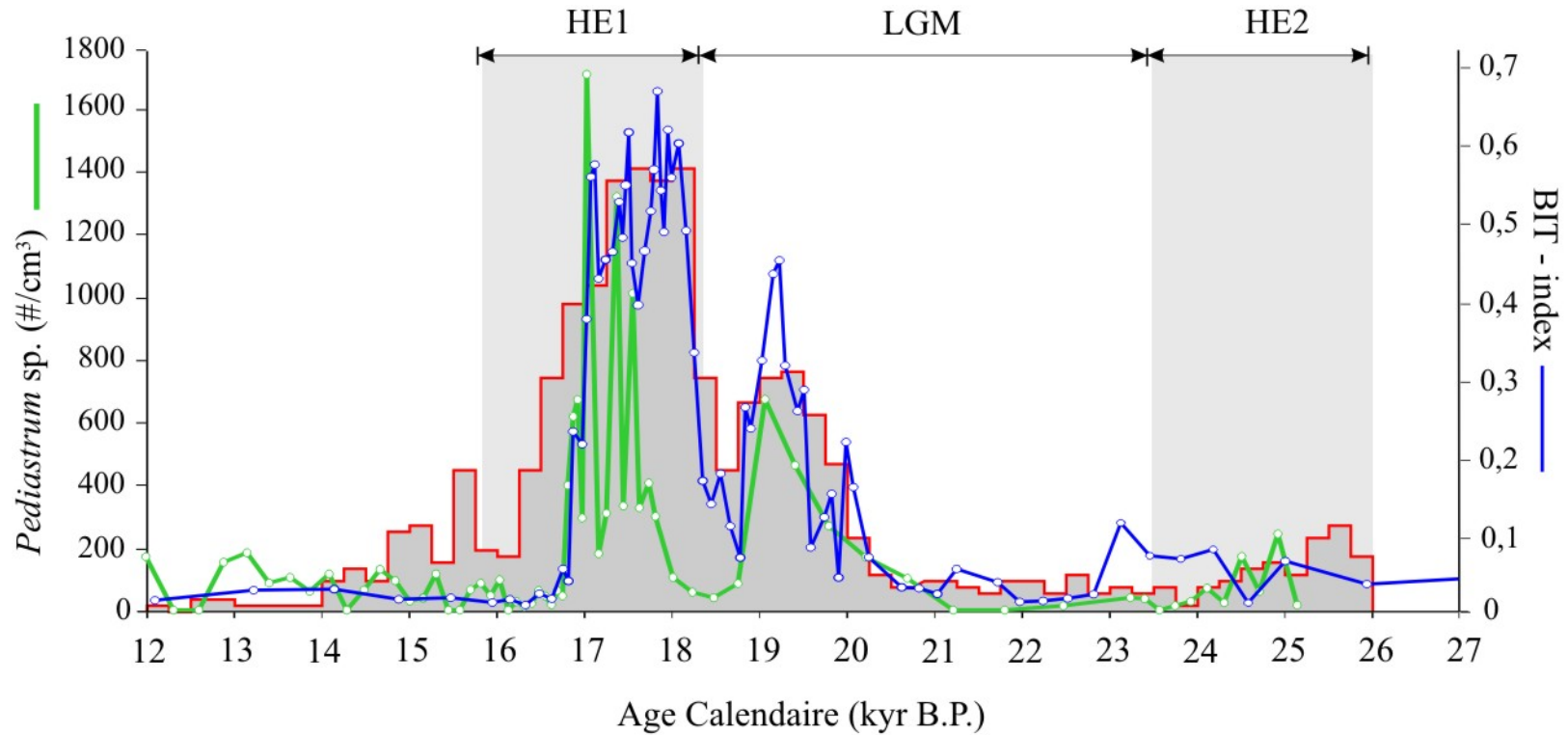


***Pediastrum* sp.** : micro-algues d'eau douce (Eynaud, 1999; Zaragosi et al., 2001)

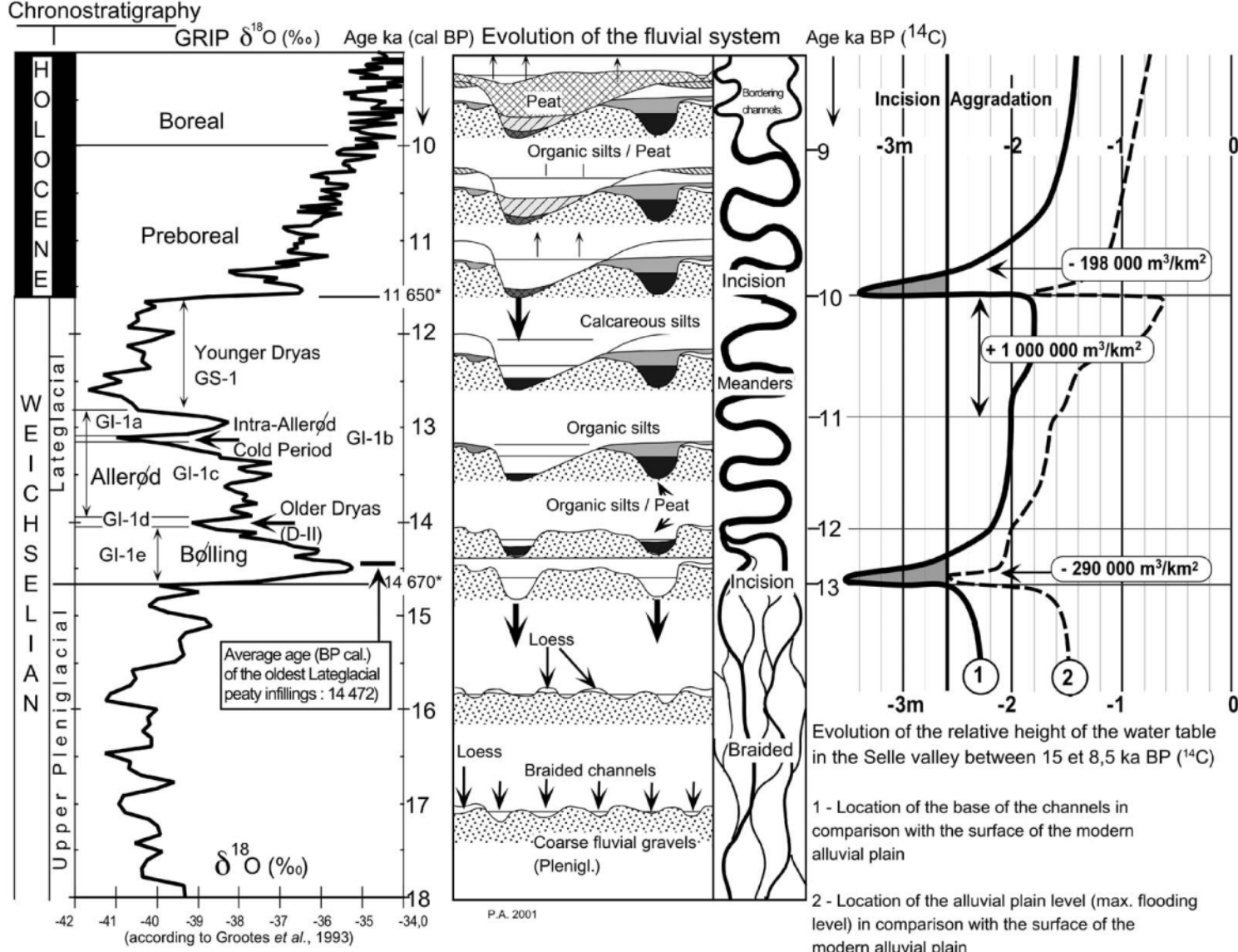
**BIT-index** : marqueur d'apports organiques d'origine continentale (Ménot et al., 2006)



# Activité turbiditique – Système Armoricaïn



Très courte période d'activité du Fleuve Manche  
(de -20 000 à -17 000 ans BP)



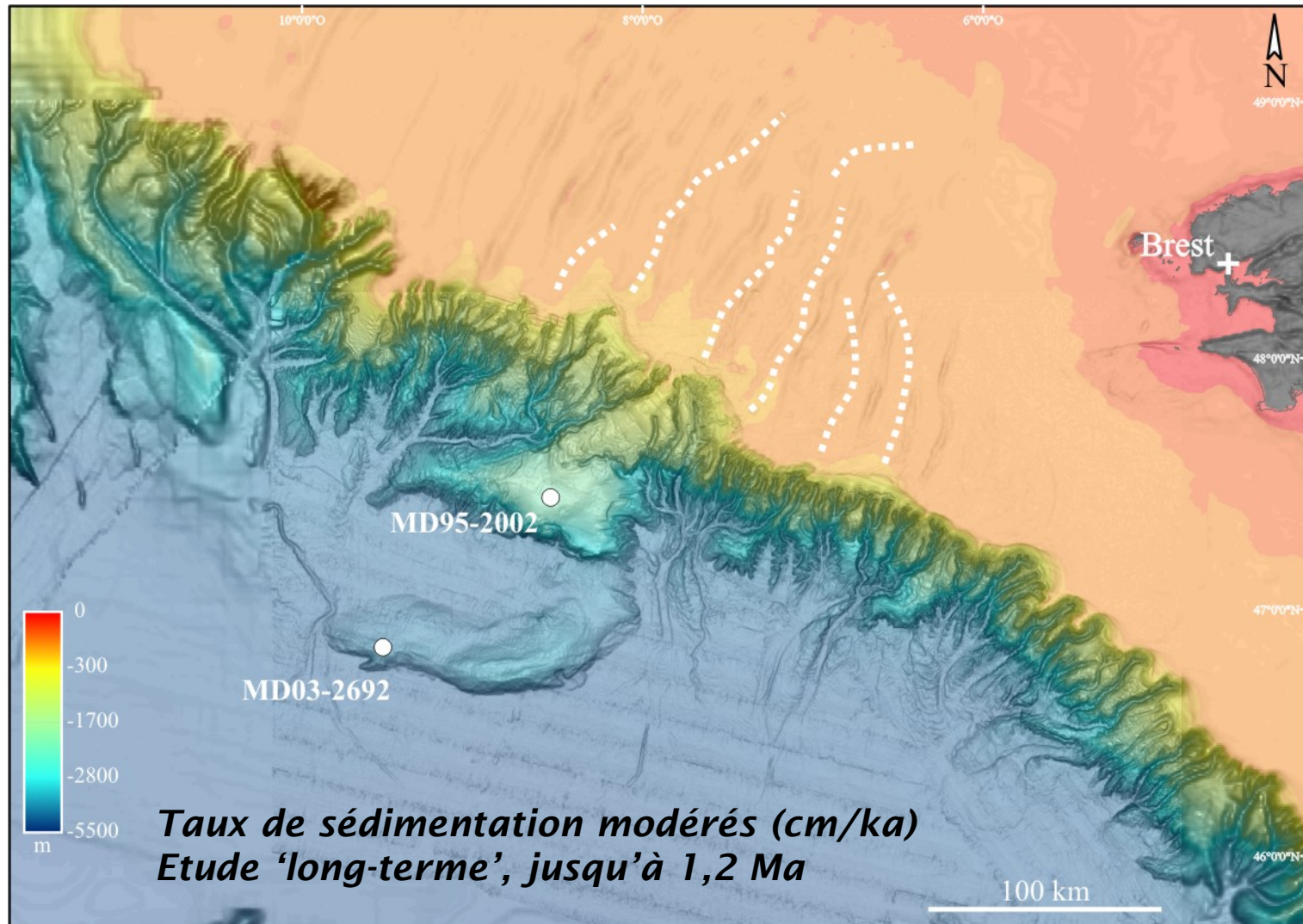
(INTIMATE Event stratigraphy according to Walker *et al.*, 1999).

\* Ages Cal. BP of the beginning of the Bølling and of the Holocene according to Stuiver *et al.*, 1995 ; Taylor *et al.*, 1997).

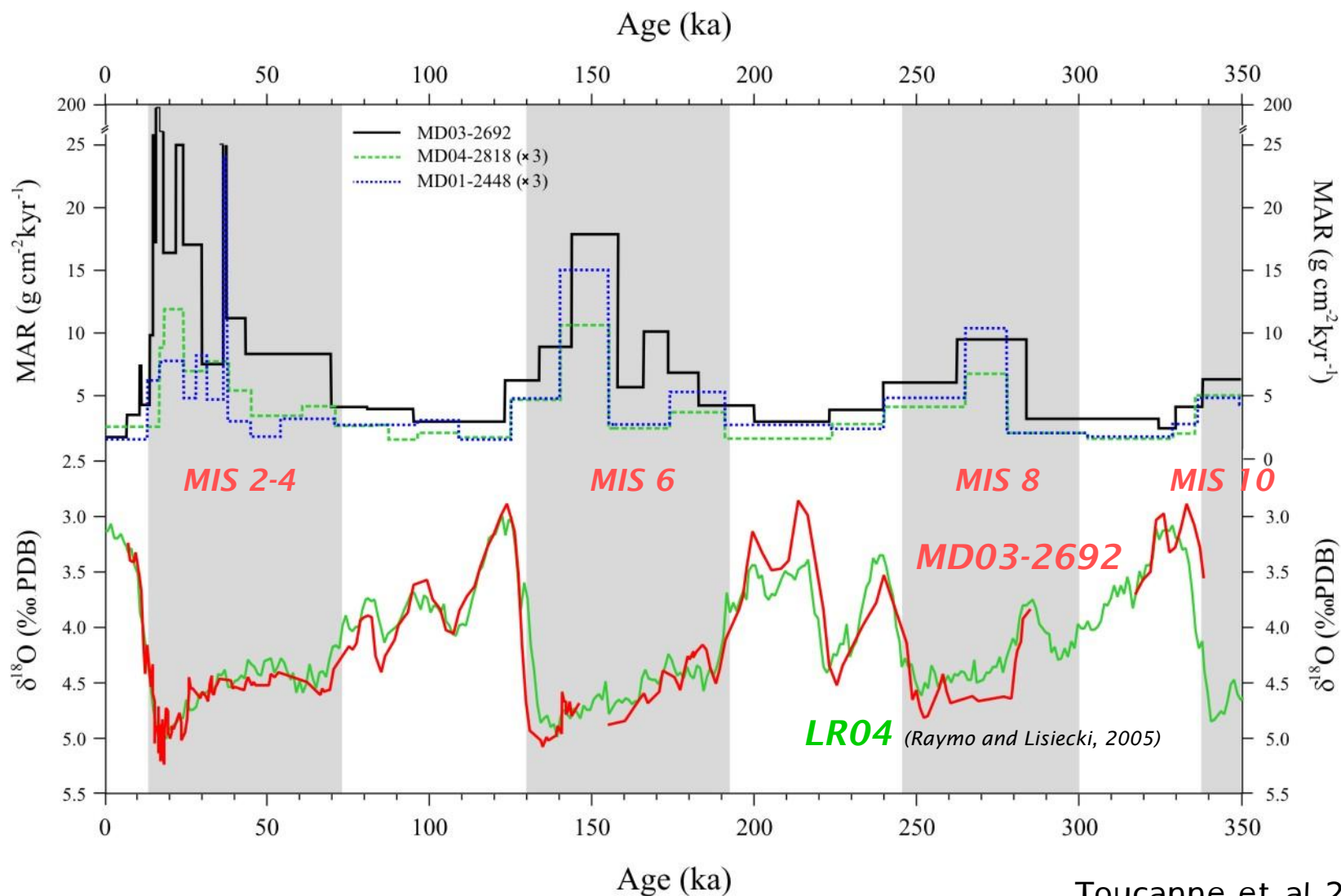
Antoine, P. et al. 2003

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Et pour les périodes plus anciennes ?

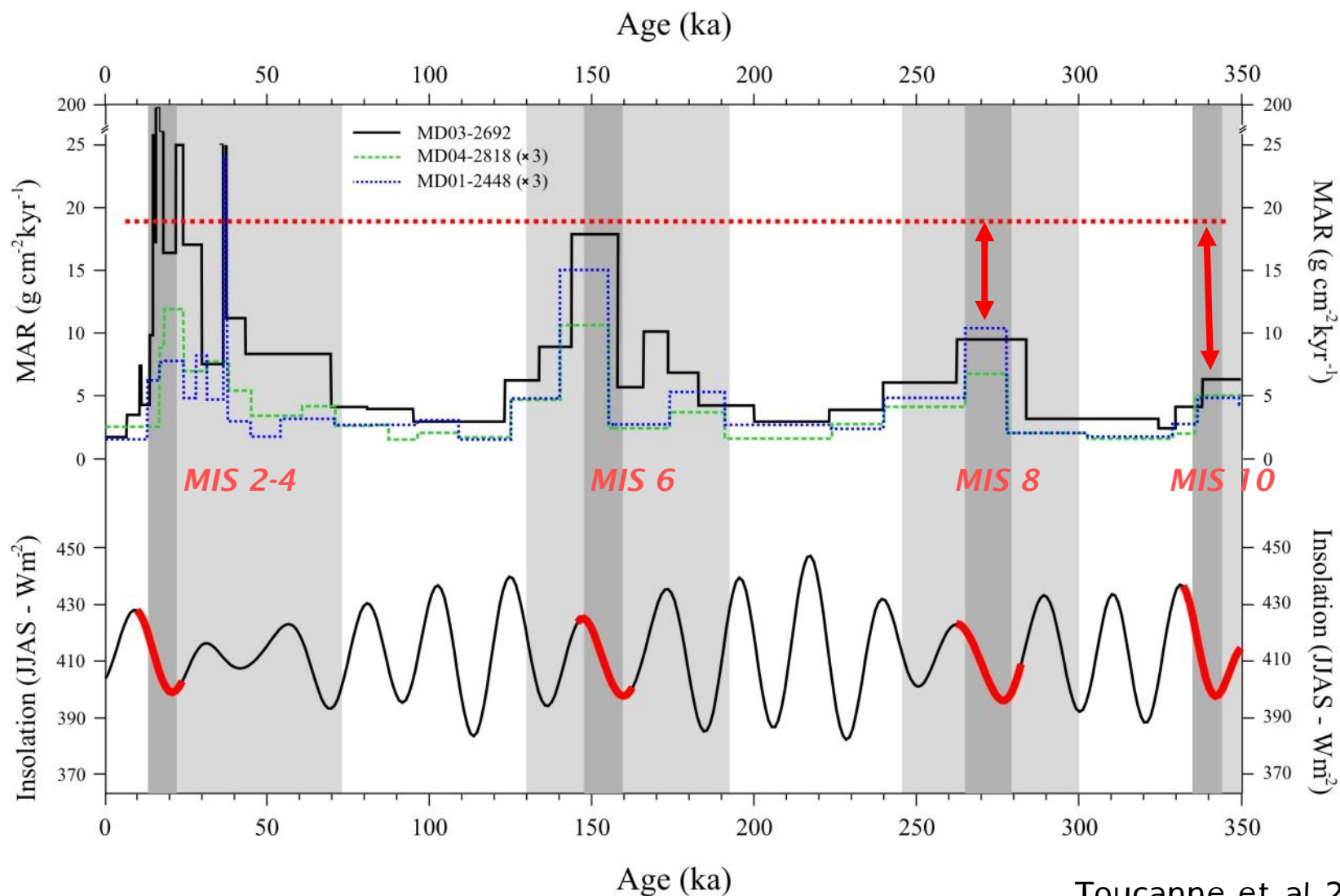


# Pour les derniers 350 000 ans



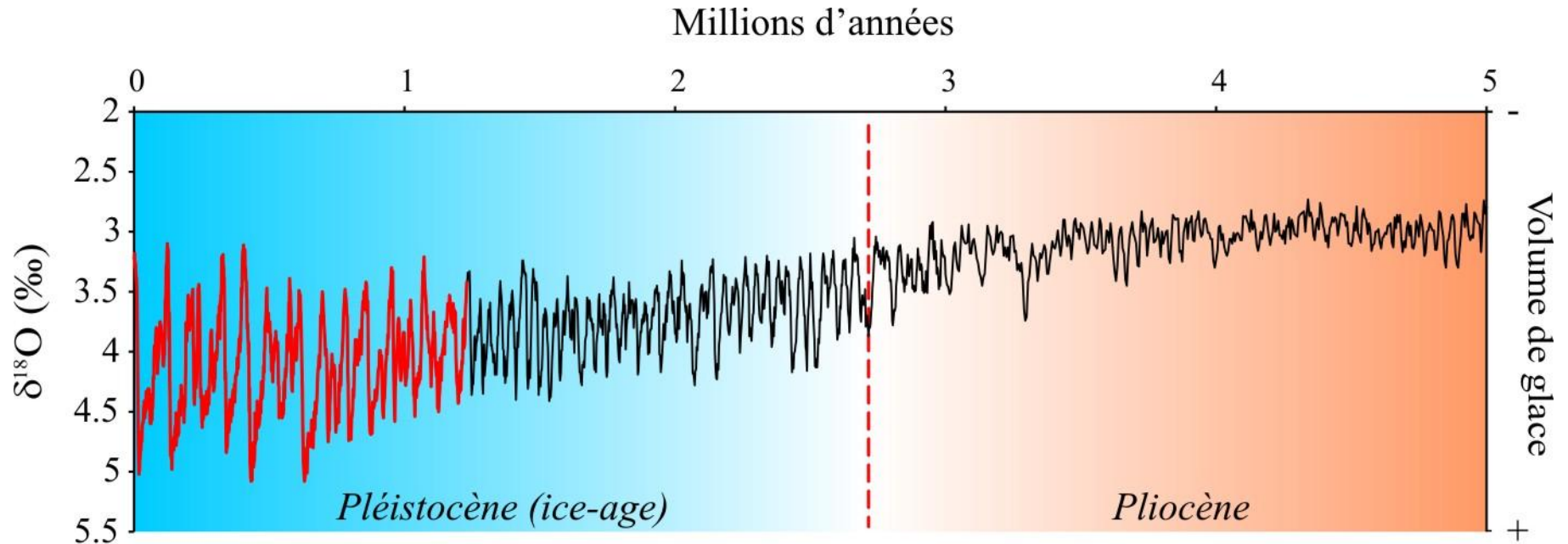
Toucanne et al 2009

# Pour les derniers 350 000 ans

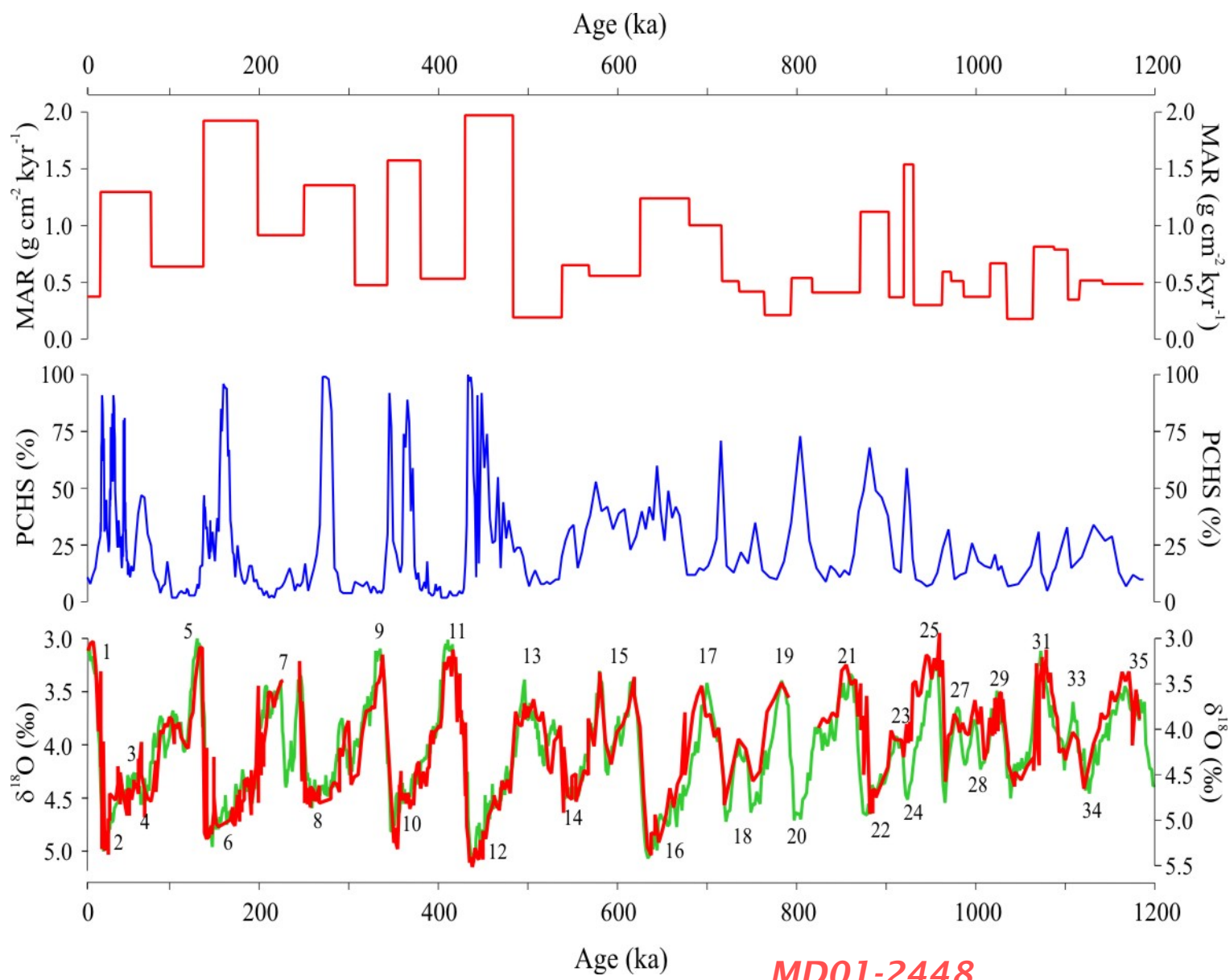


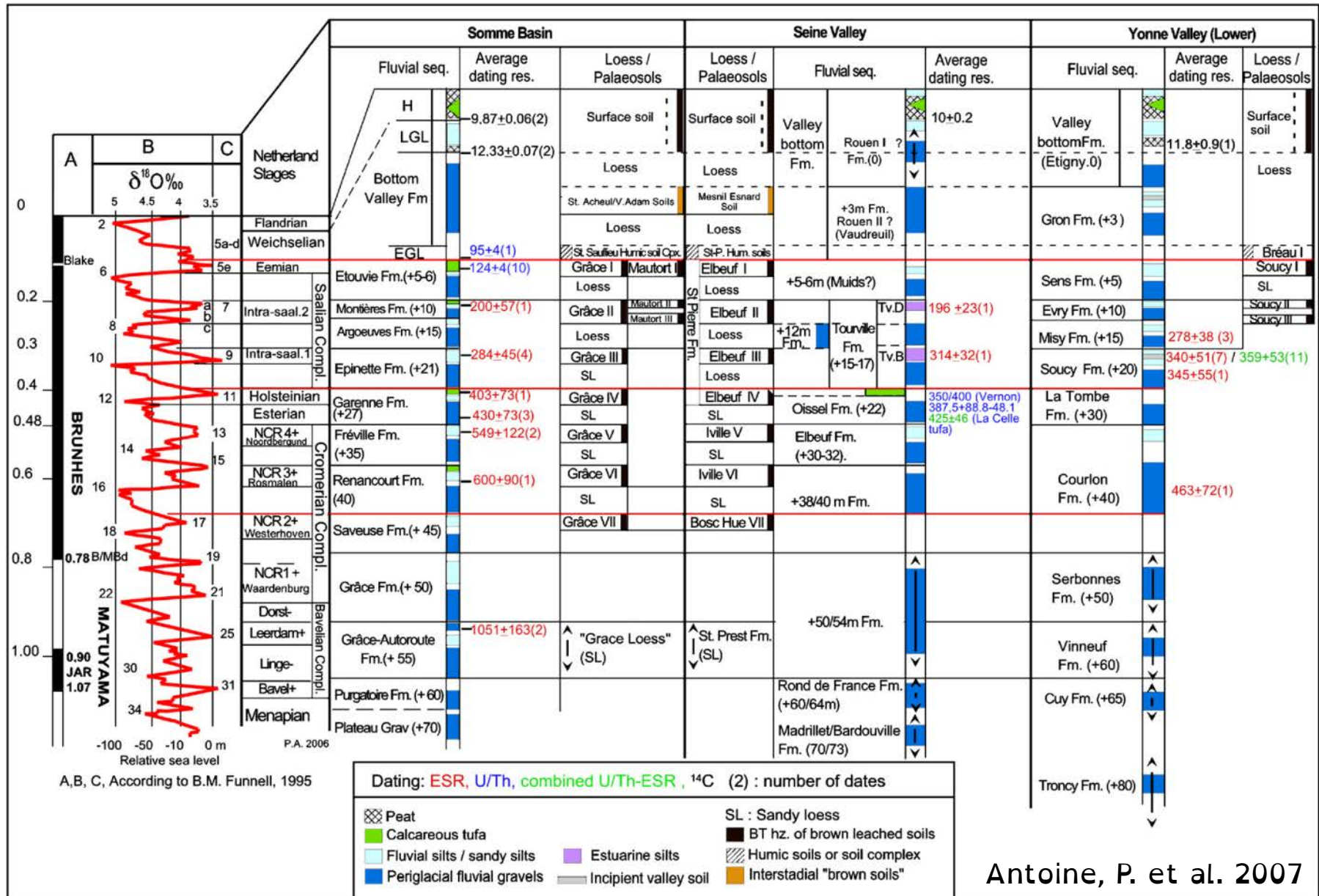
Toucanne et al 2009

## Pour les derniers 1 200 000 ans



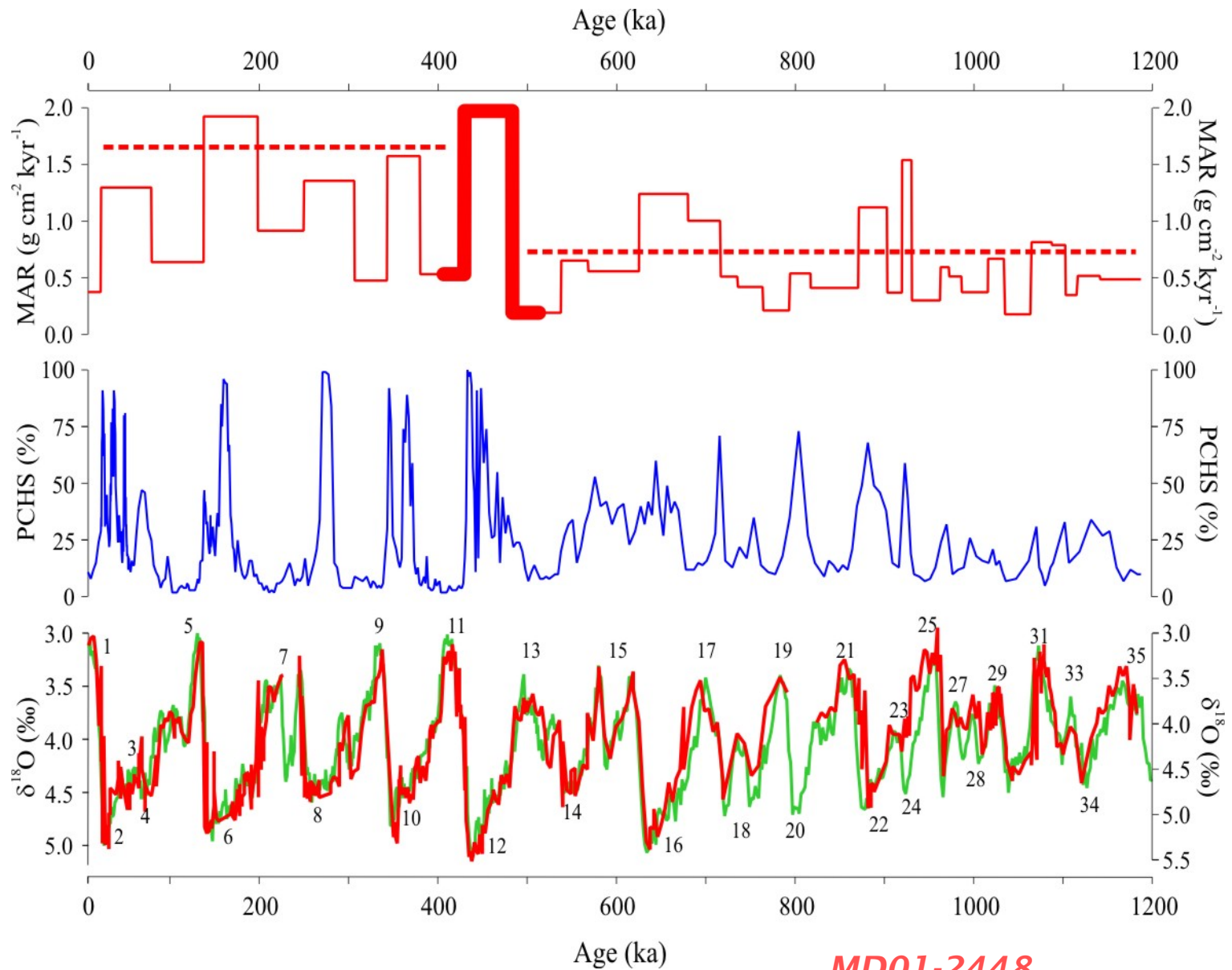
Toucanne 2008



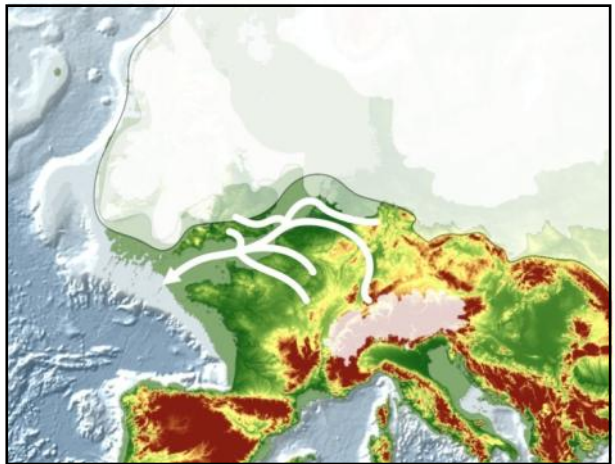
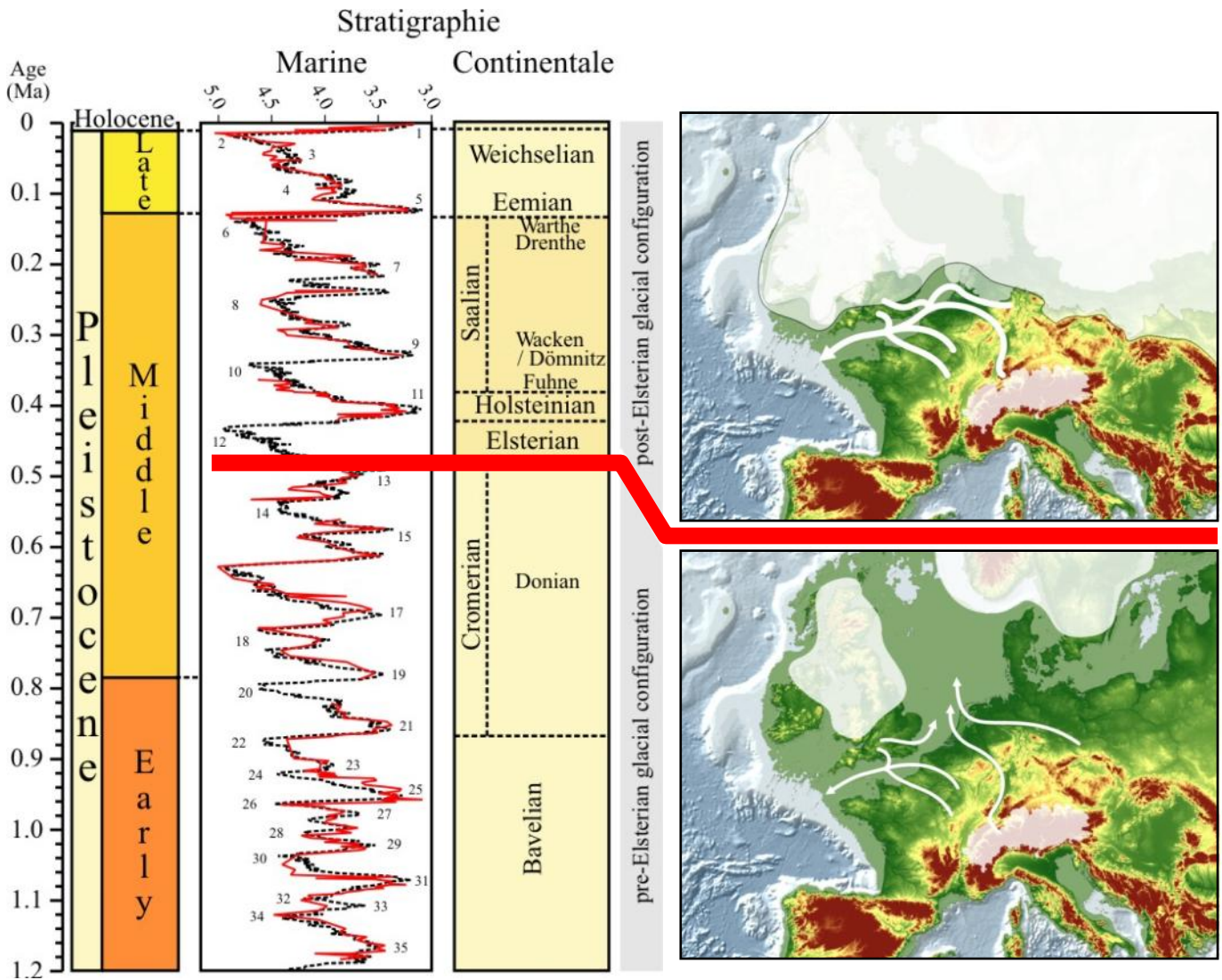


Antoine, P. et al. 2007

Synthetic table of the Pleistocene formations of the Seine, Some and Yonne basin. Average dating results and correlation with global NW European chronostratigraphy and the global sea-level curve

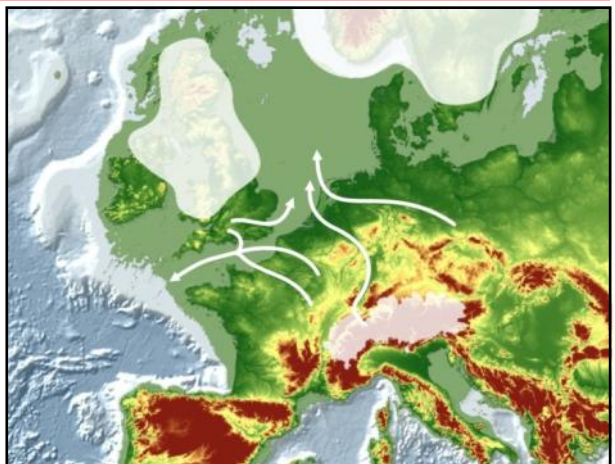


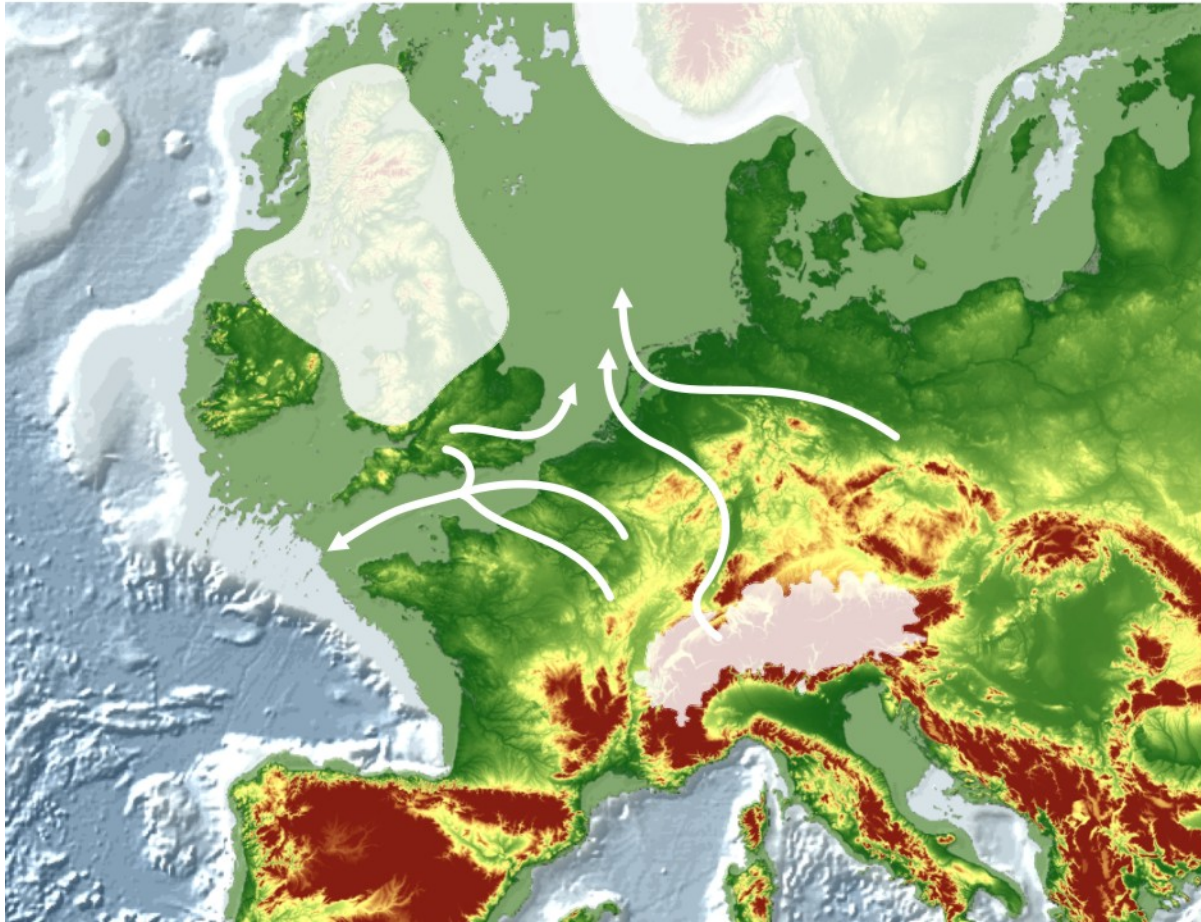
**MD01-2448**



**Glaciation Elstérienne = MIS 12**

➔ *Première diversion des fleuves d'Europe Centrale vers le Sud*

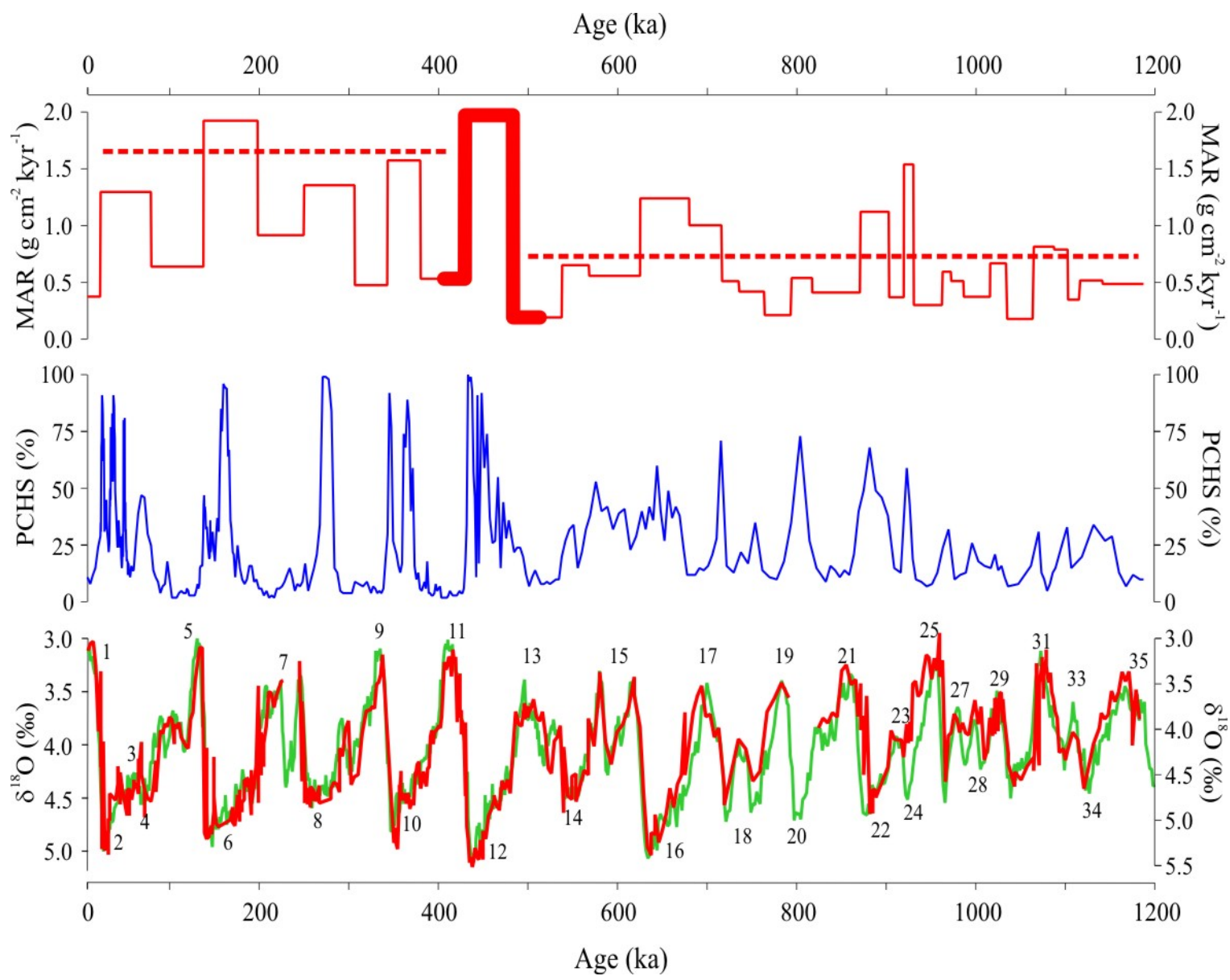




***Configuration pré-Elstérienne (i.e. avant MIS 12)***  
***Drainage des fleuves d'Europe Centrale = Mer du Nord***  
***Drainage des fleuves Nord France + Sud Angleterre = Manche***



***Configuration post-Elstérienne (MIS 12, 6 et 2)***  
***Déviation du réseau de drainage européen vers la Manche***  
***MIS 12 = ouverture du Détroit du Pas-de-Calais + isolement de la Grande-Bretagne ?***



**MD01-2448** Toucanne et al 2009

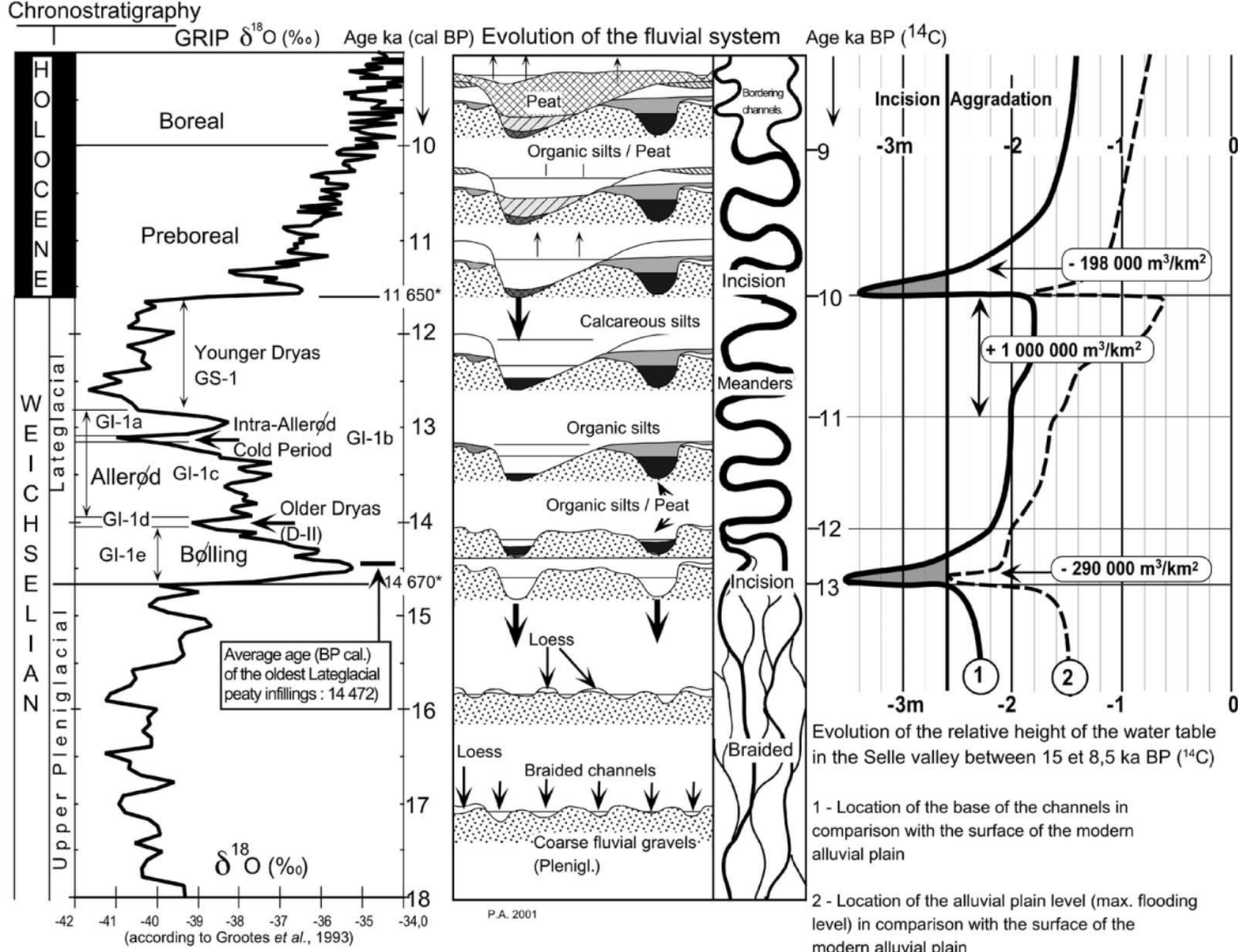


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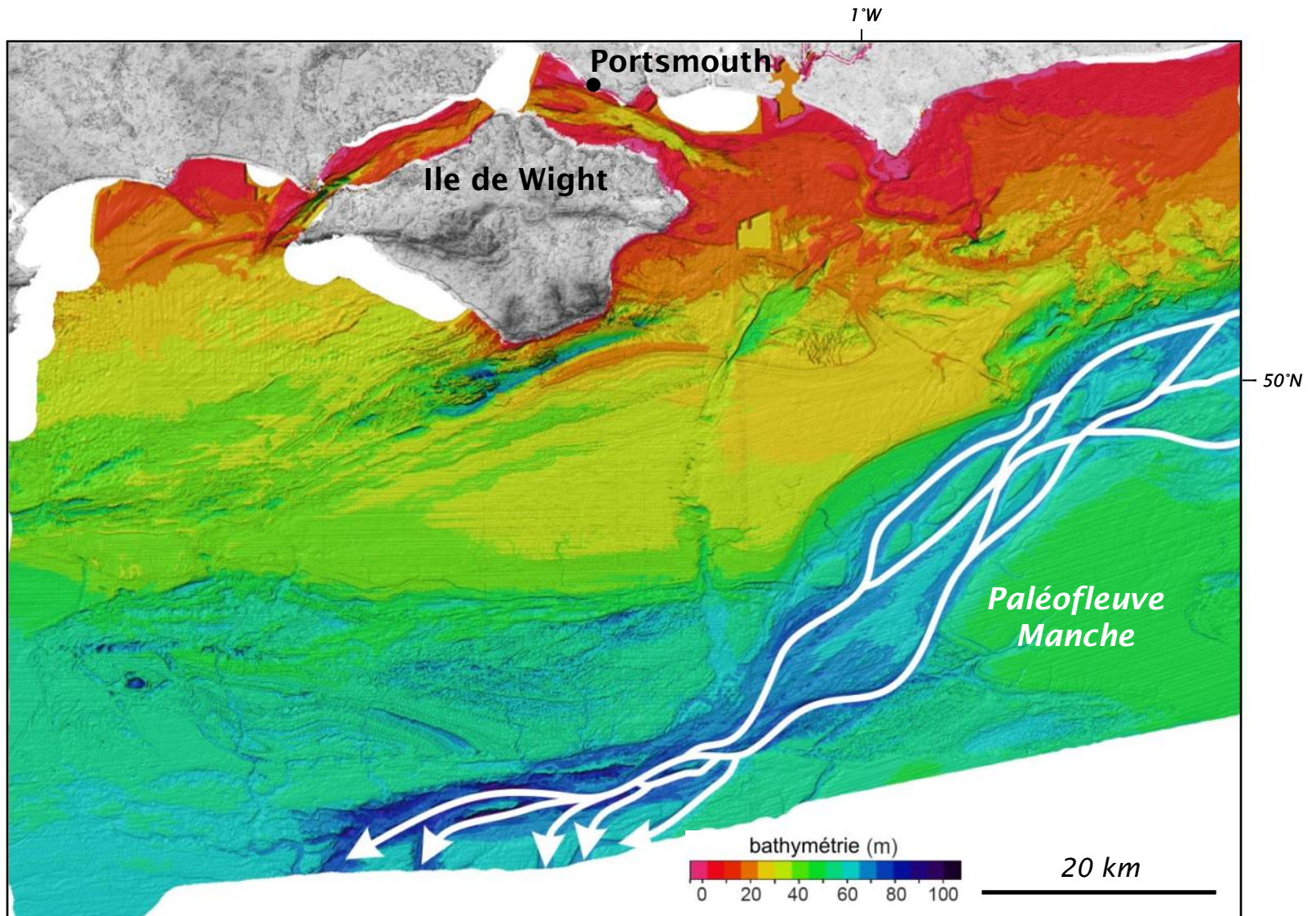


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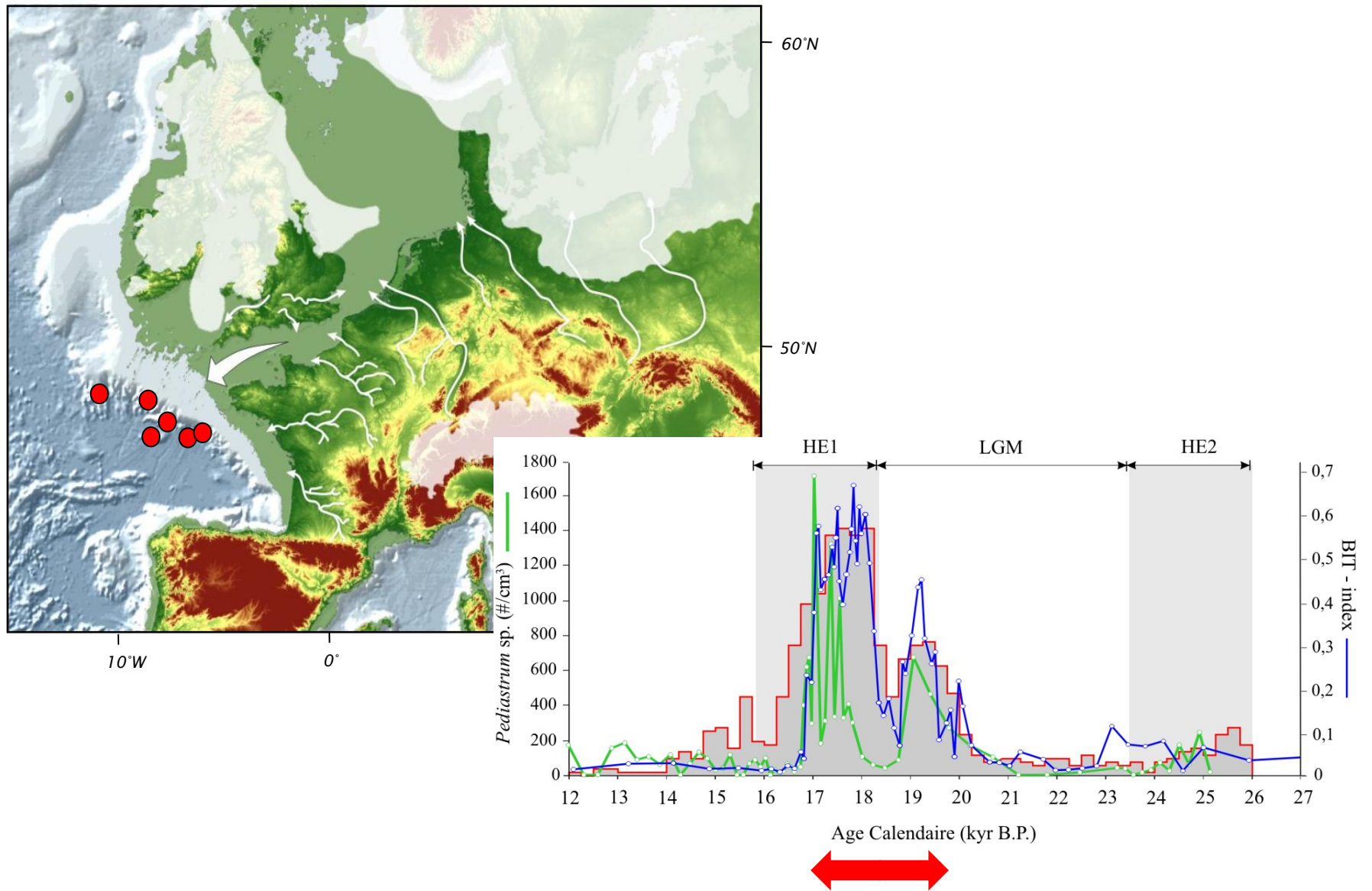
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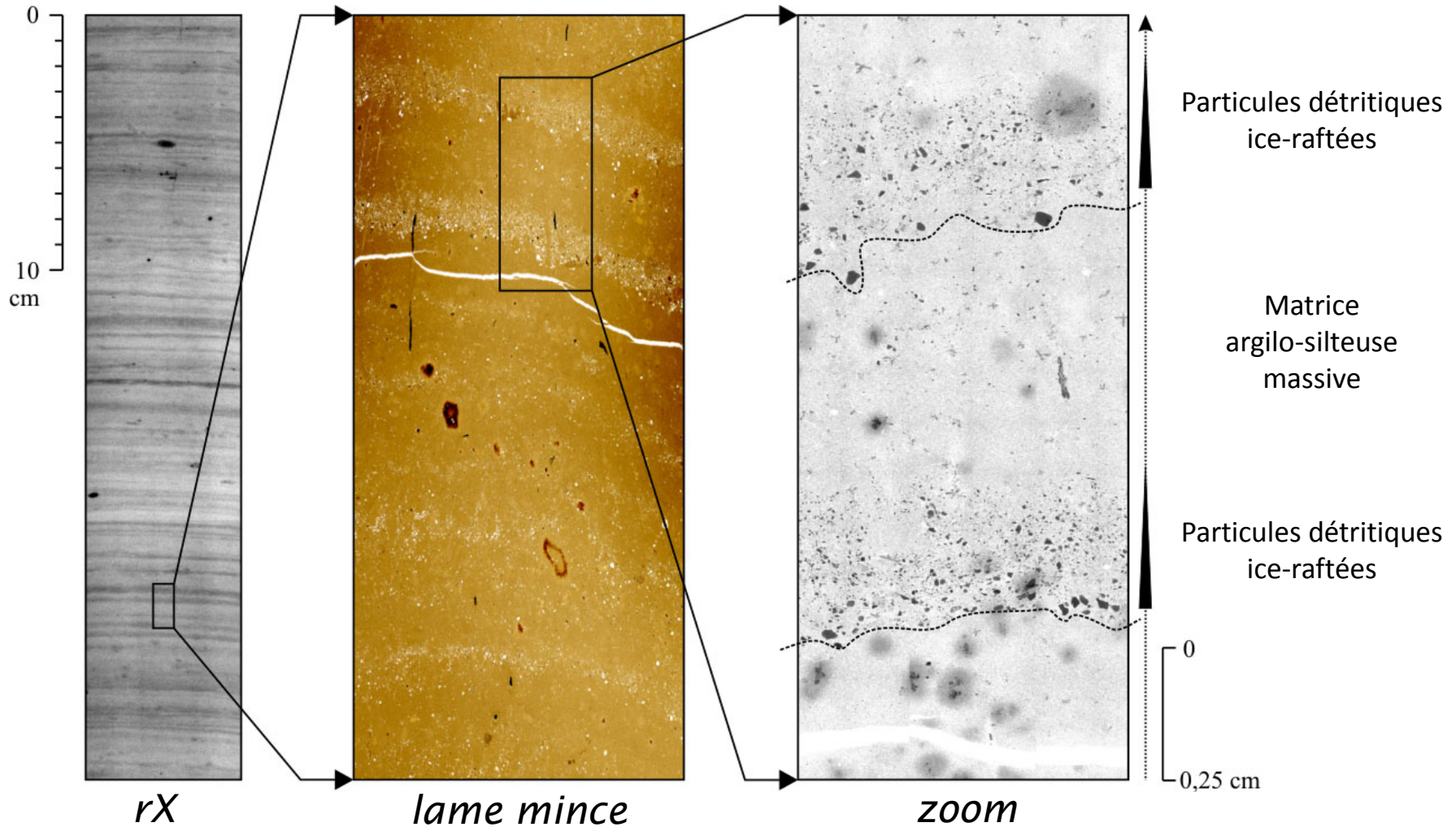


Gupta et al., Nature, 2007

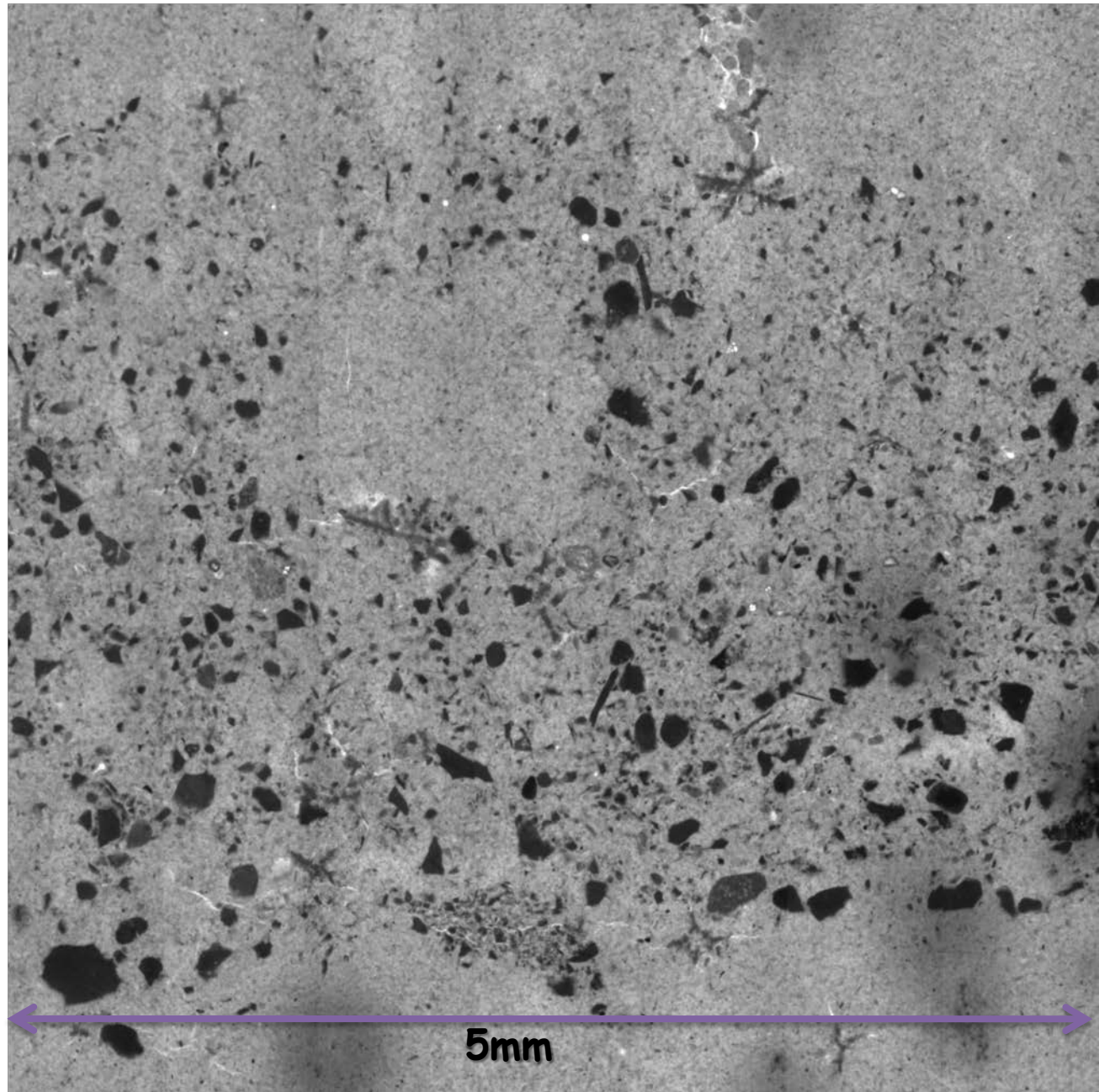


***Période d'activité du Fleuve Manche***

# Faciès Laminé (18,3-17 ka)

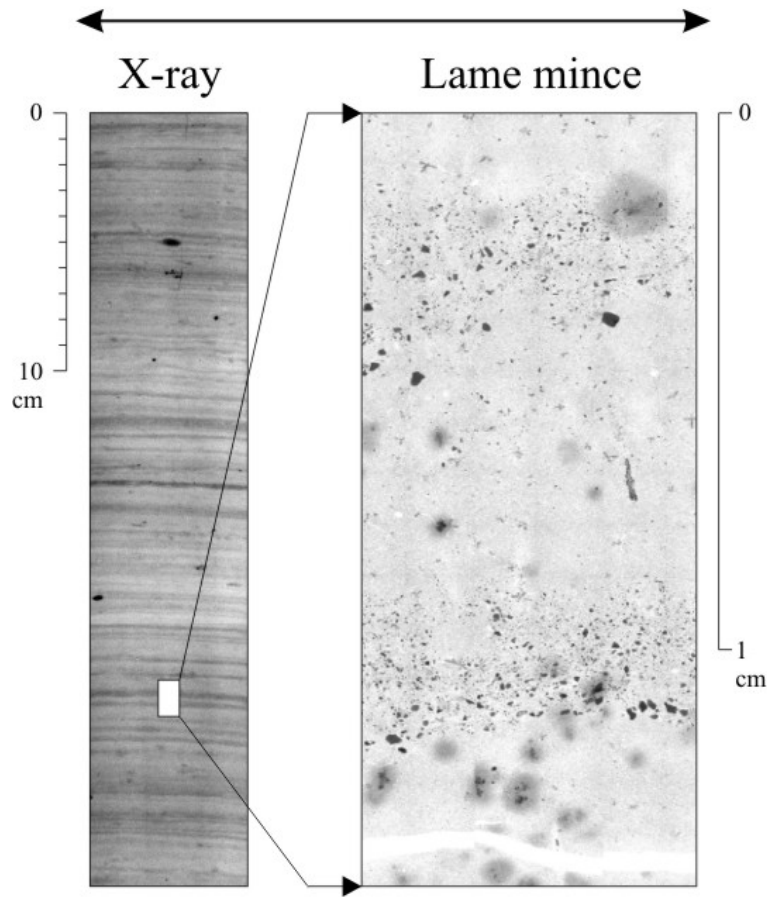


## Faciès Laminé (18,3-17 ka)

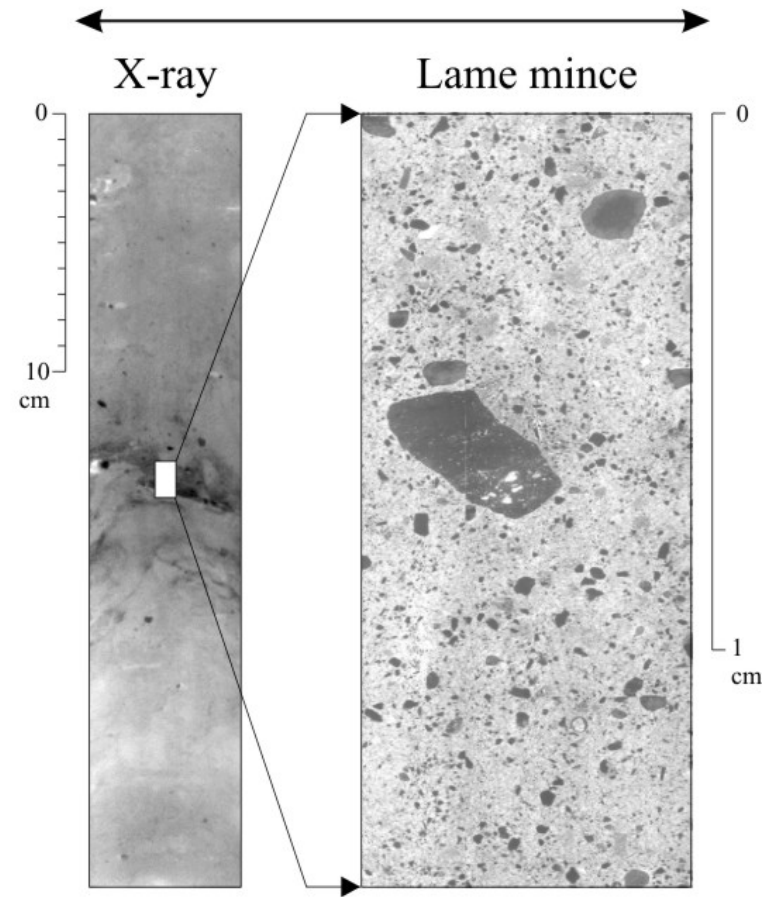


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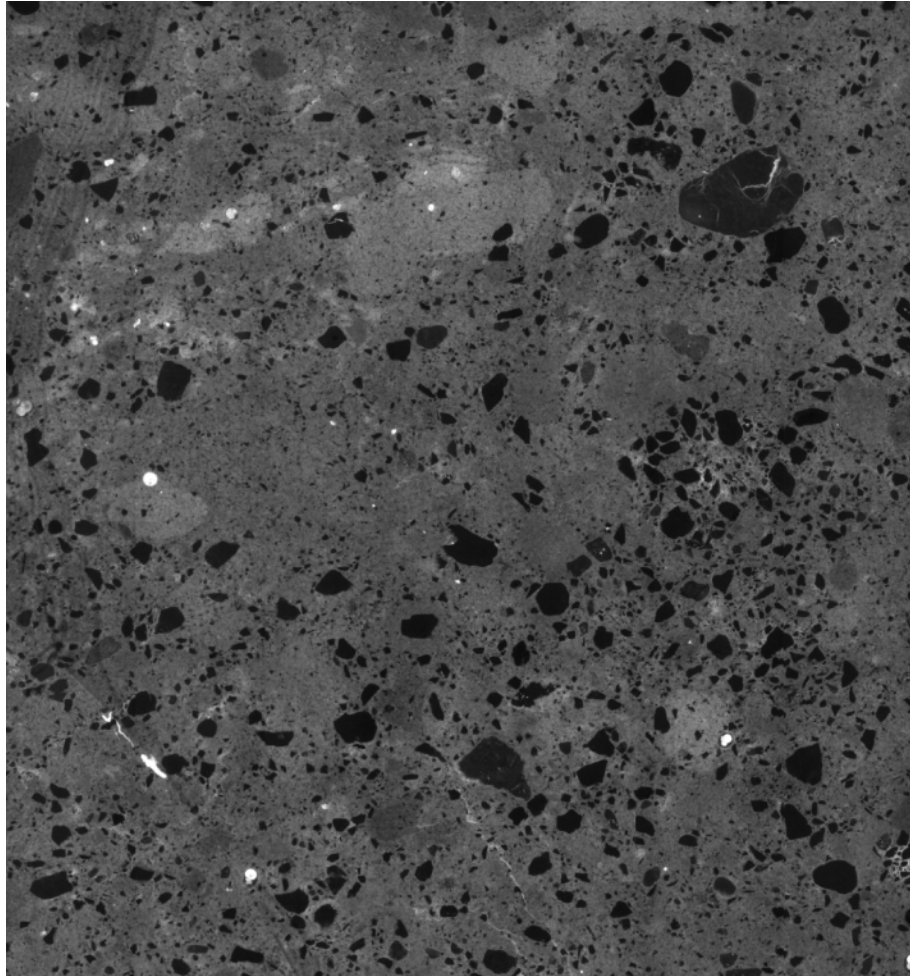
*Faciès Laminé (18,3-17 ka)*



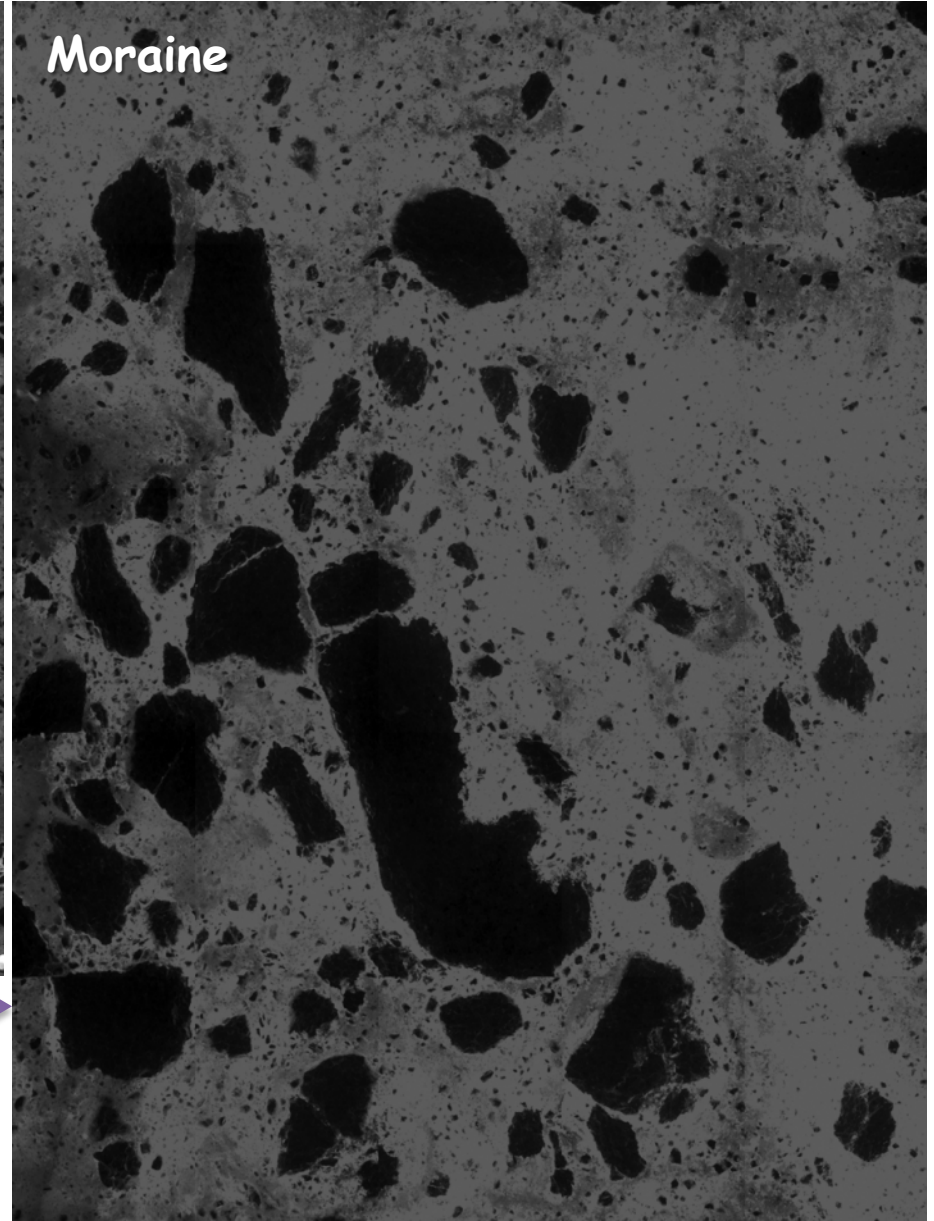
*Niveau de Heinrich (17-16 ka)*



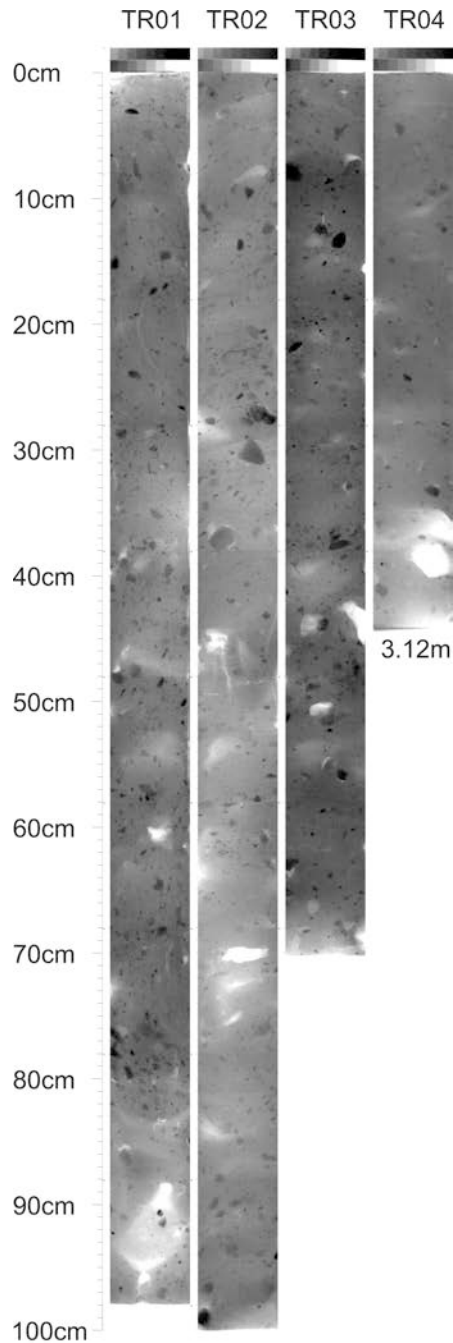
Toucanne 2008



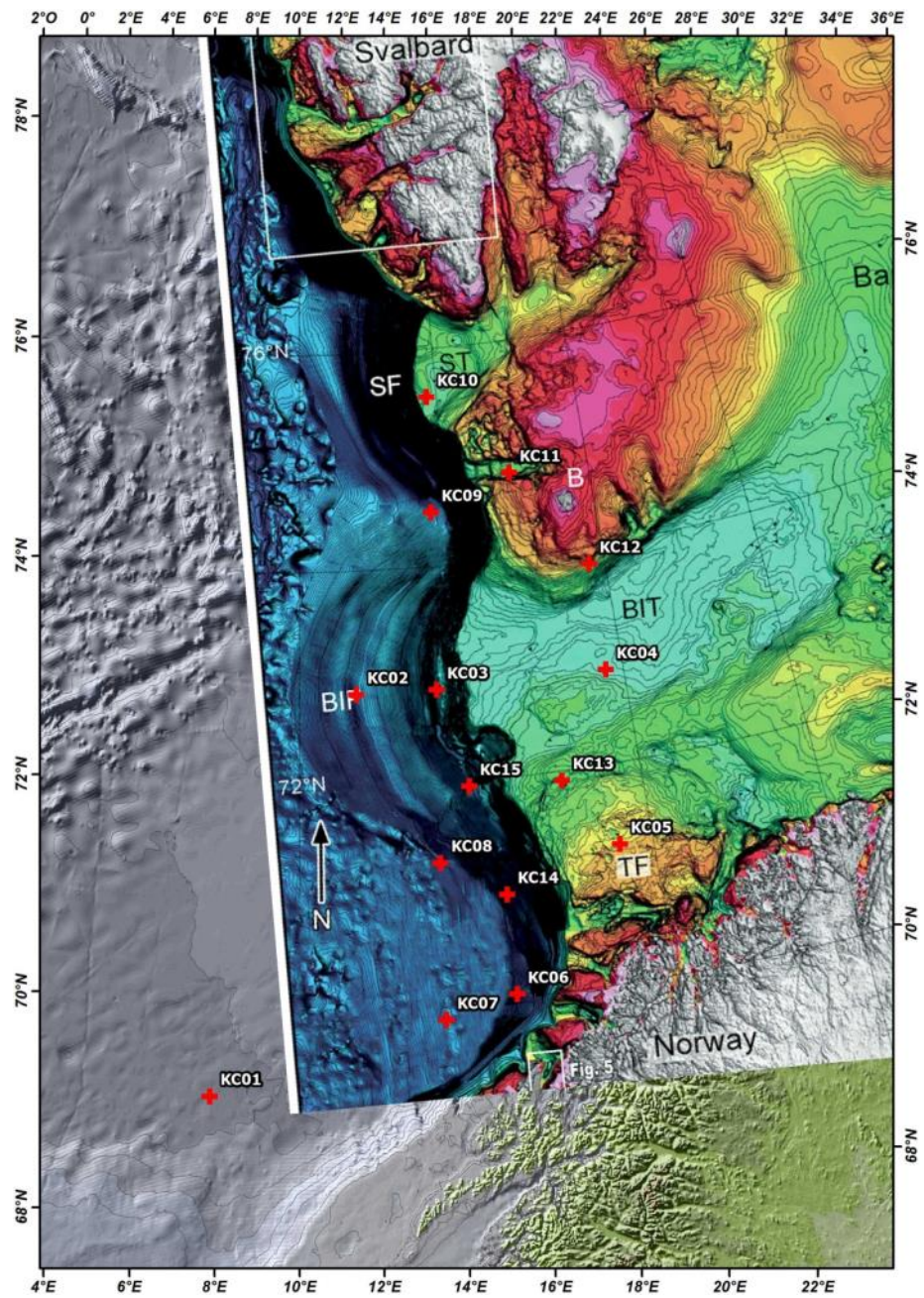
Moraine



← 1cm →

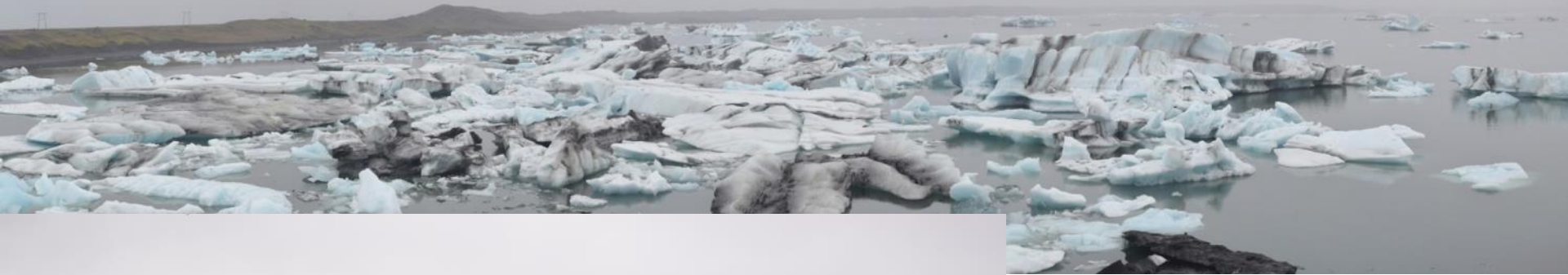


MOCOSED2014 KC13



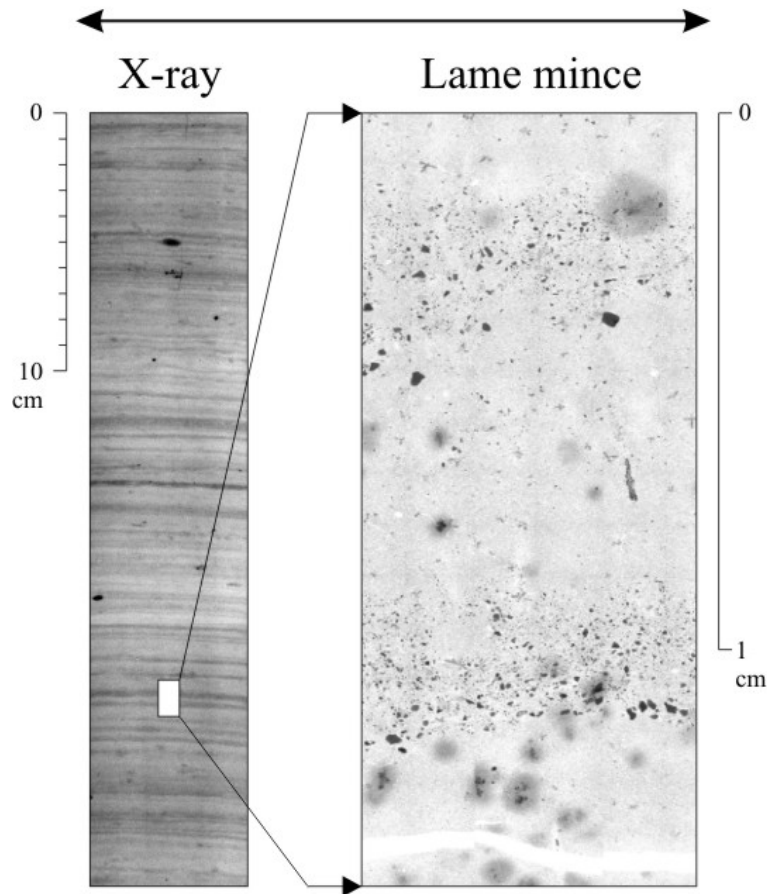
Ottesen et al , 2005

# Lac glaciaire Jökulsárlón Islande Juillet 2014

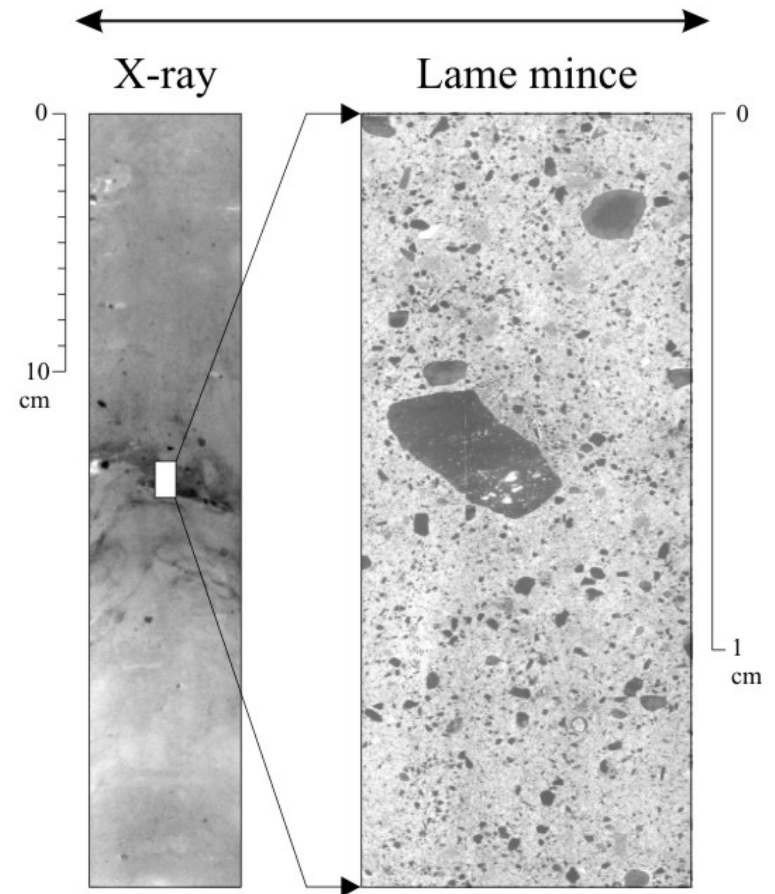


# Faciès Laminé (18,3-17 ka)

## Faciès Laminé (18,3-17 ka)

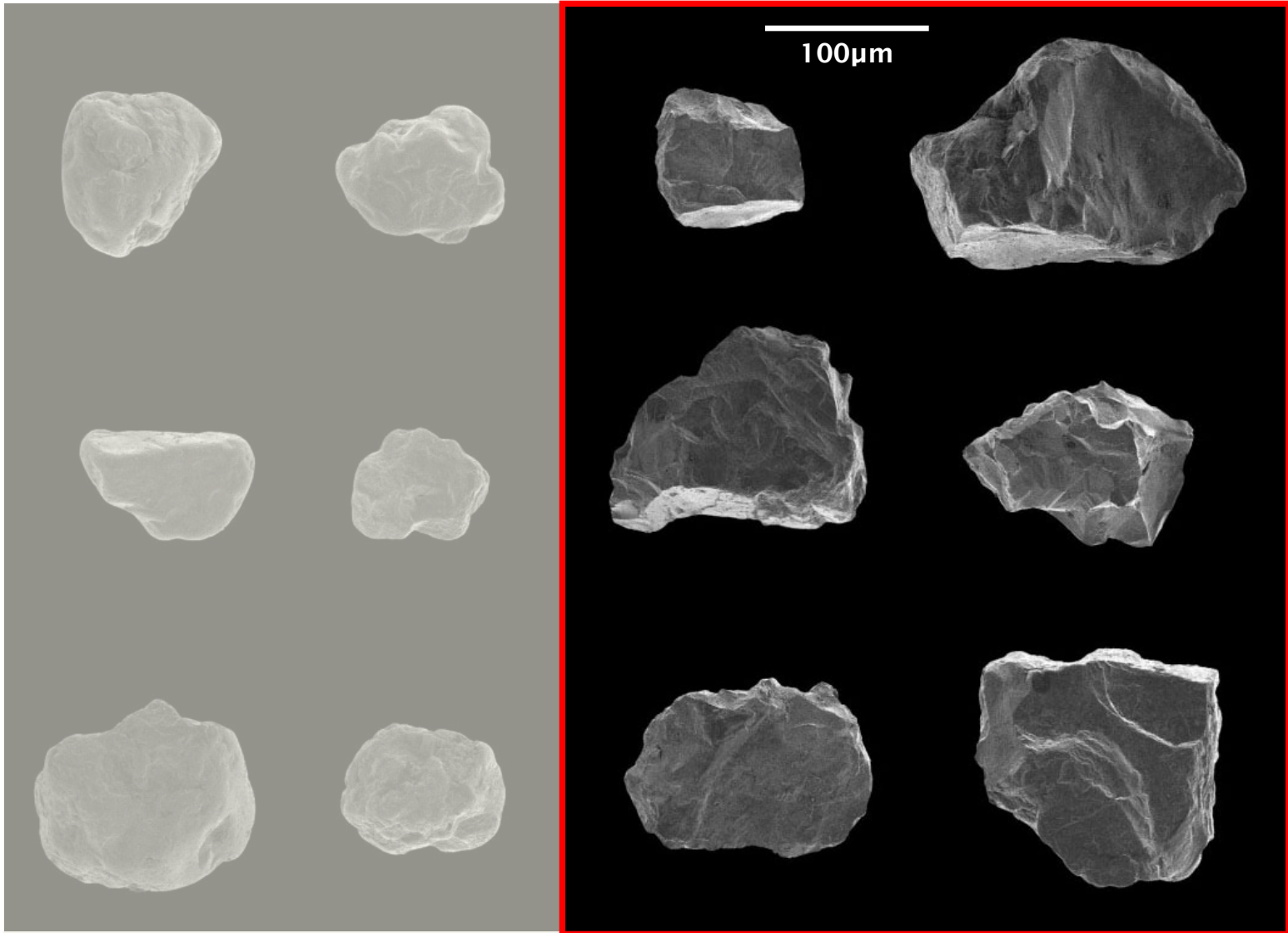


## Niveau de Heinrich (17-16 ka)

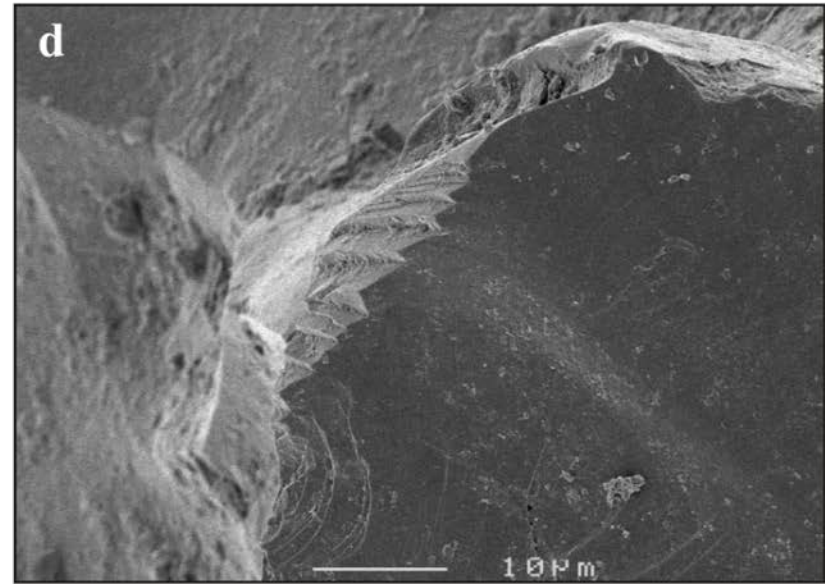
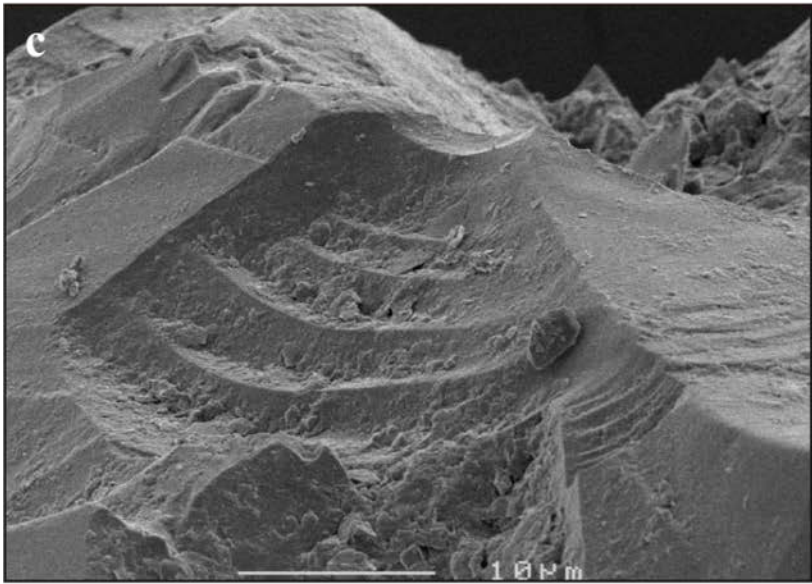
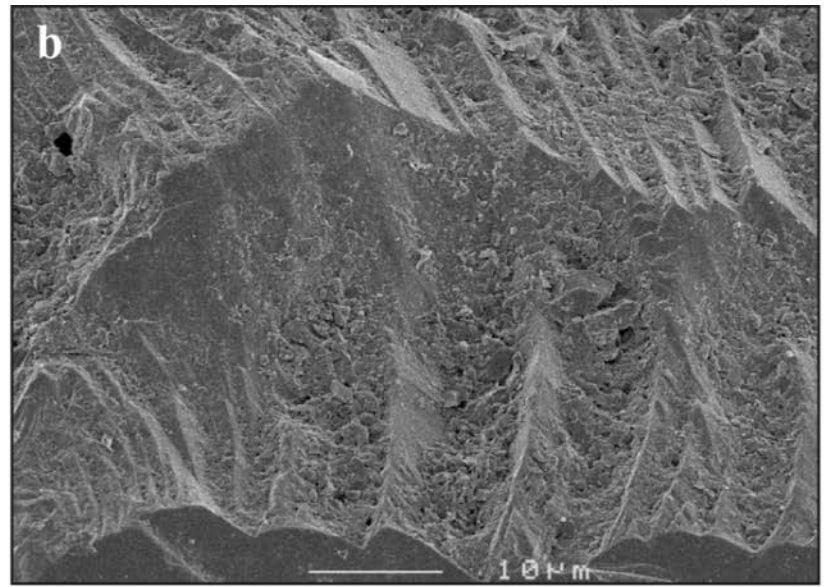
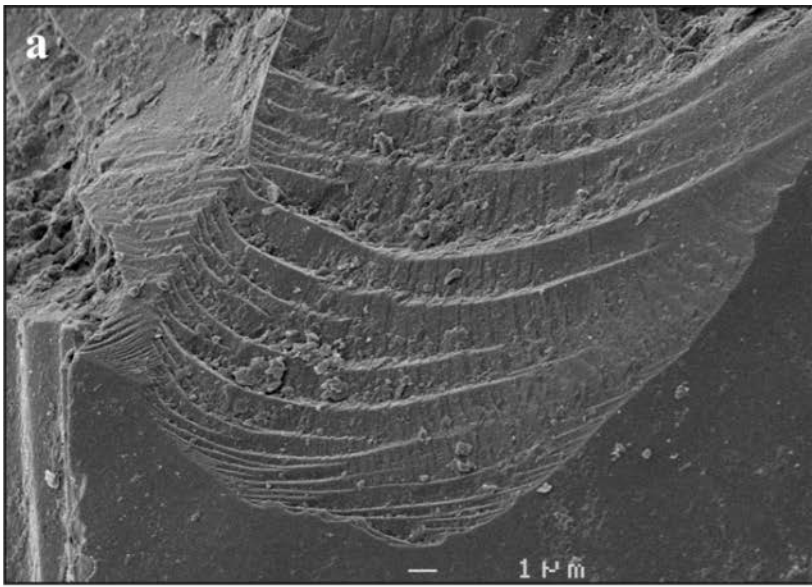


Mise en place par icebergs (calotte Laurentide)

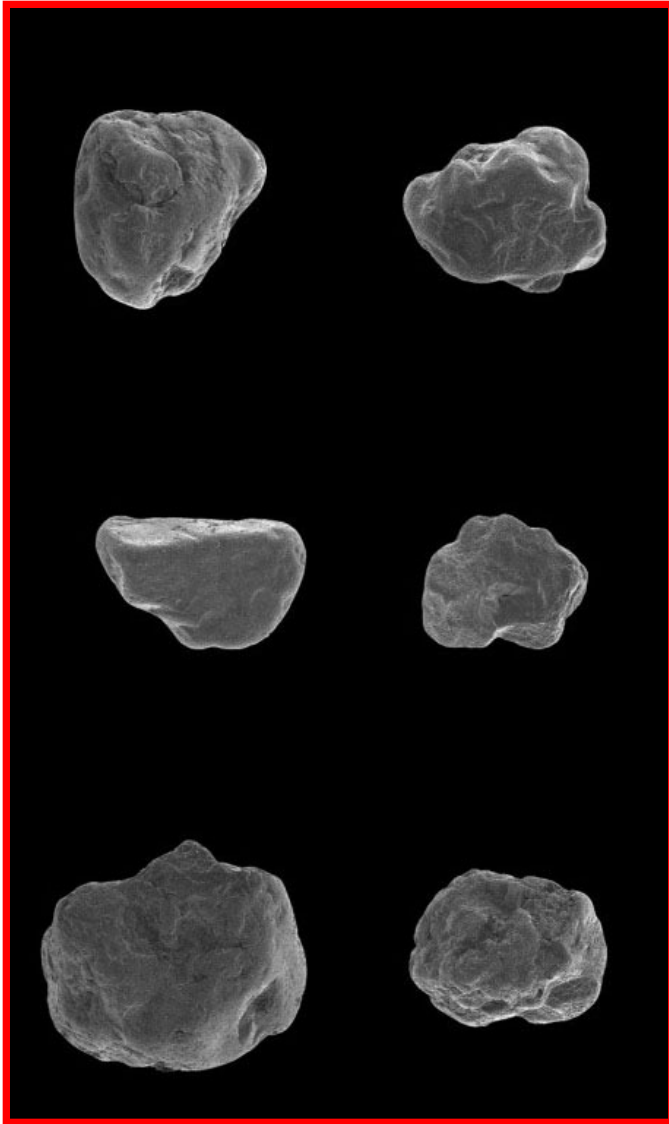




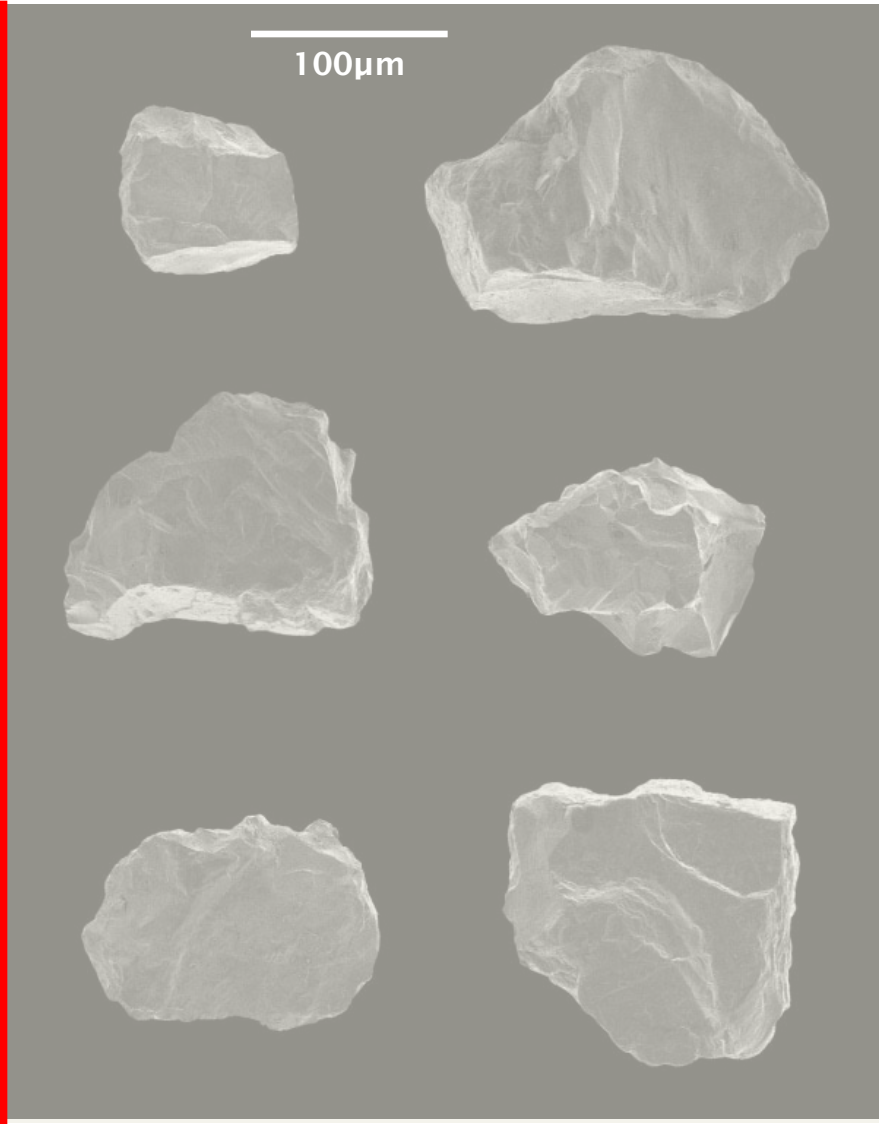
Niveau de Heinrich



***Fractures conchoïdales = érosion / origine glaciaire***  
(d'après la classification de Krinsley and Doorkamp, 1973)

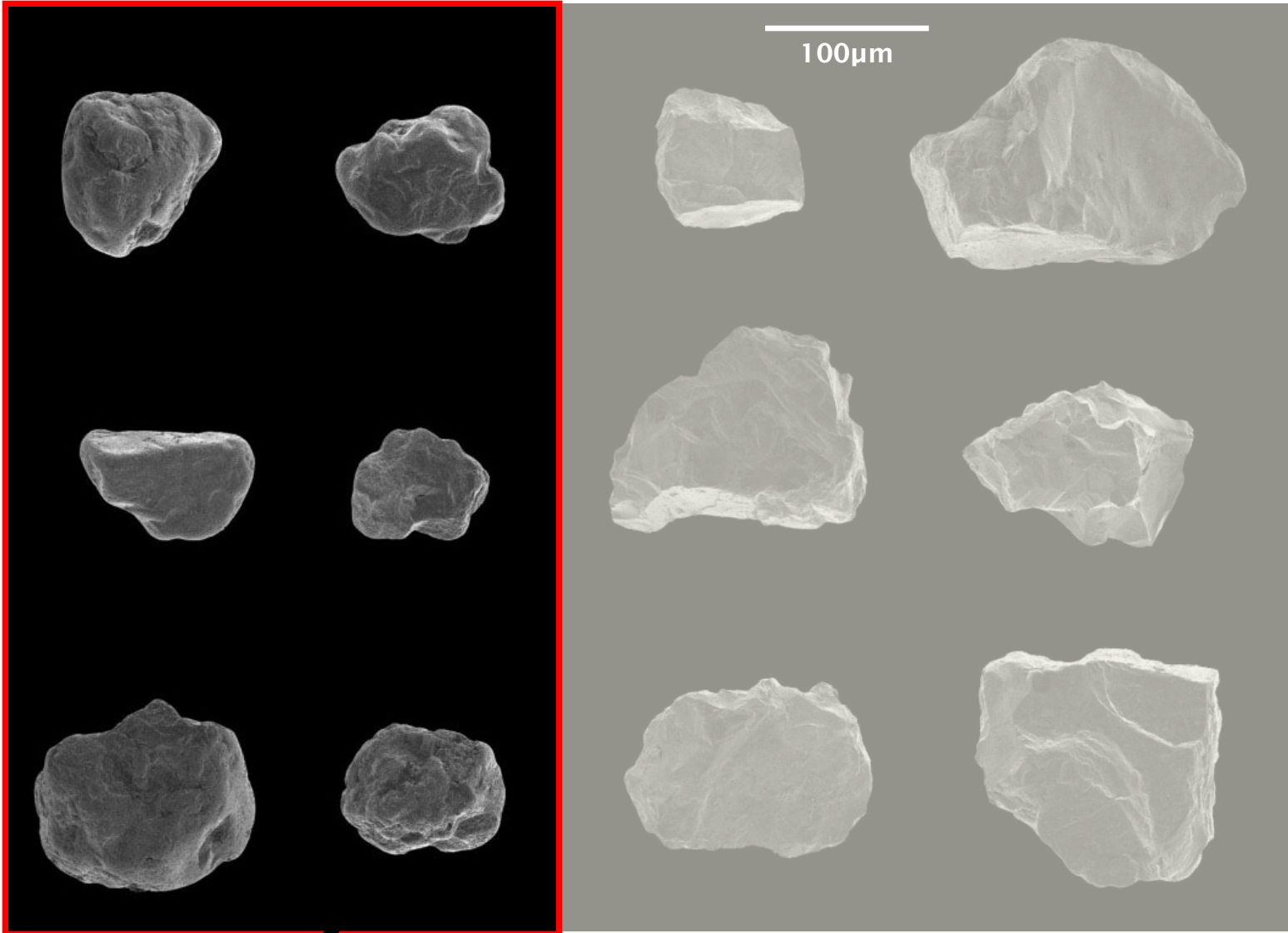


Faciès Laminé



Niveau de Heinrich

Toucanne 2008

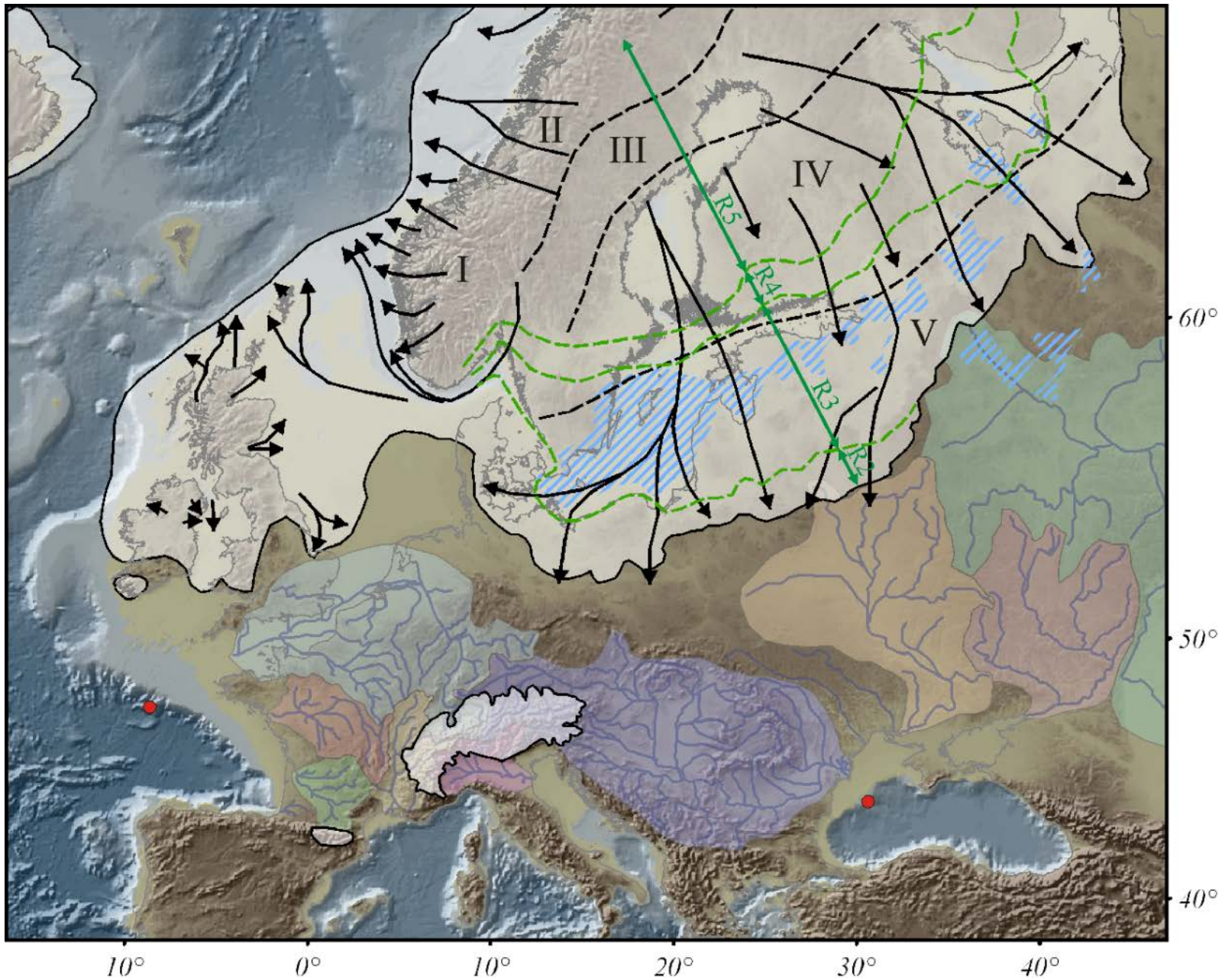


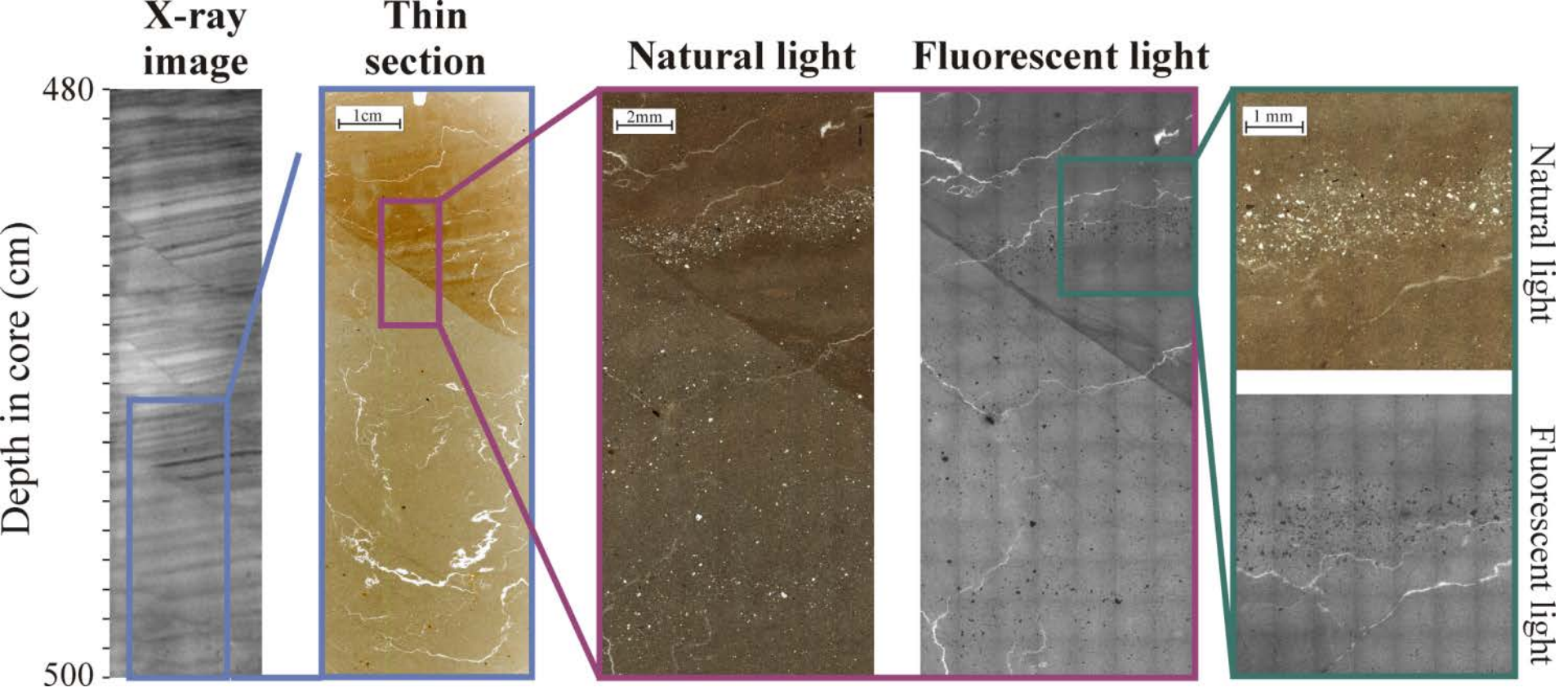
**Origine fluviale**

(d'après la classification de Krinsley and Doorkamp, 1973)



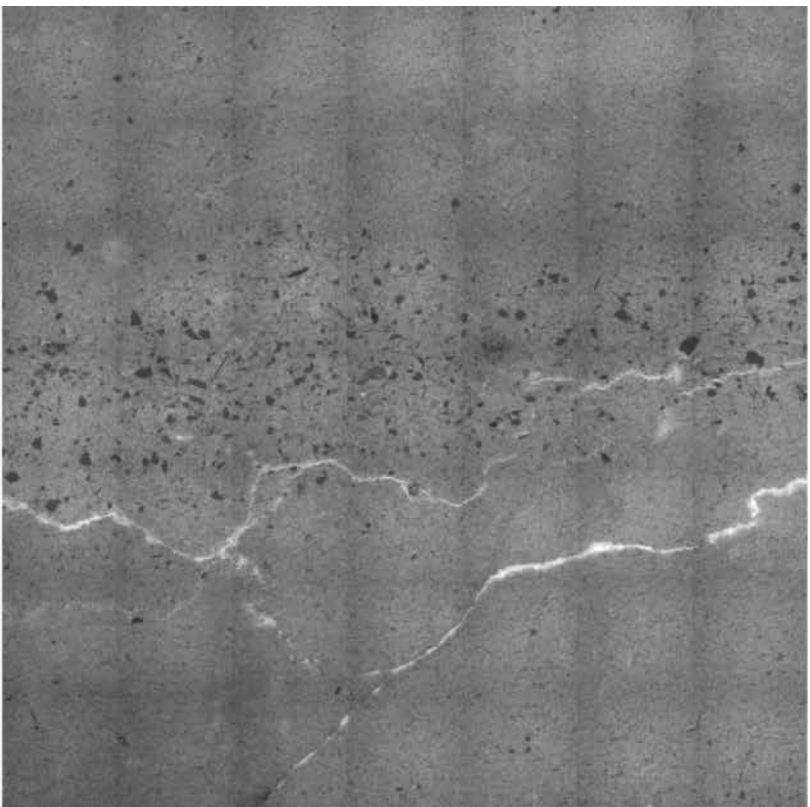






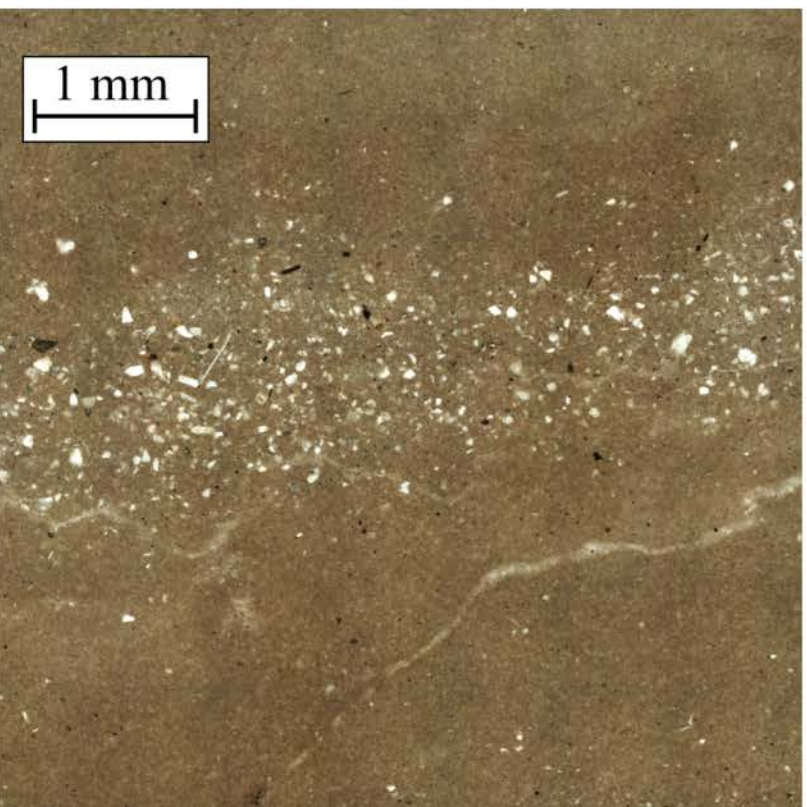
**MD042790**

Fluorescent light



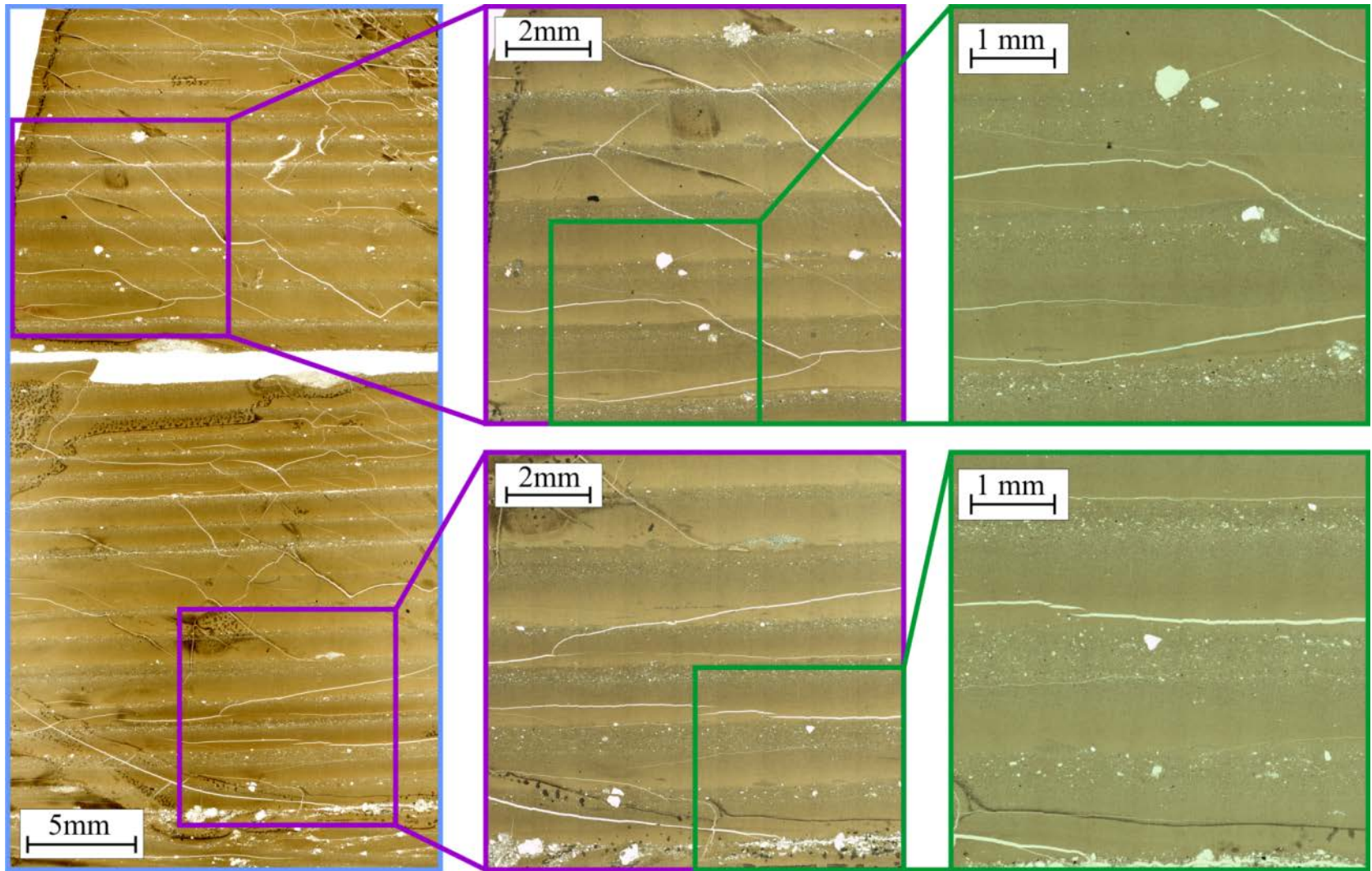
MD042790

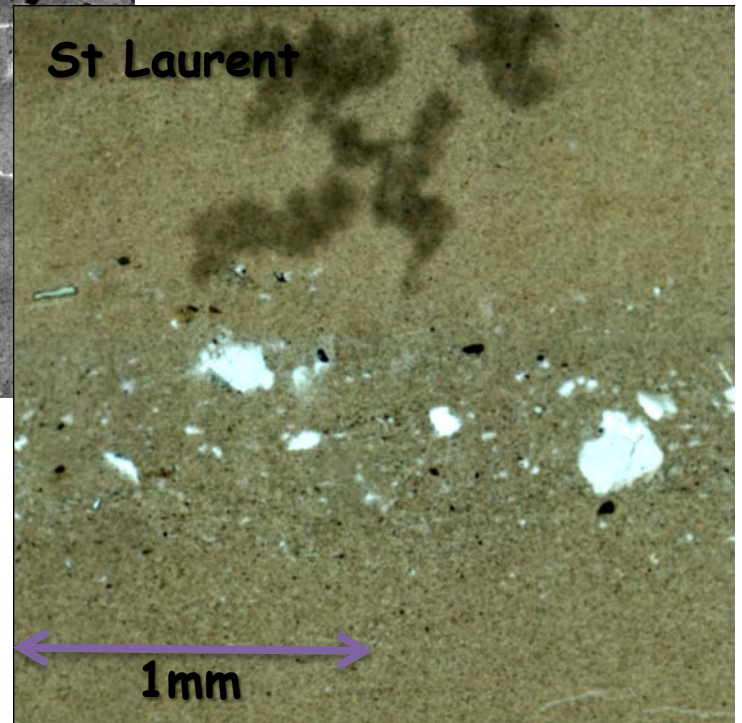
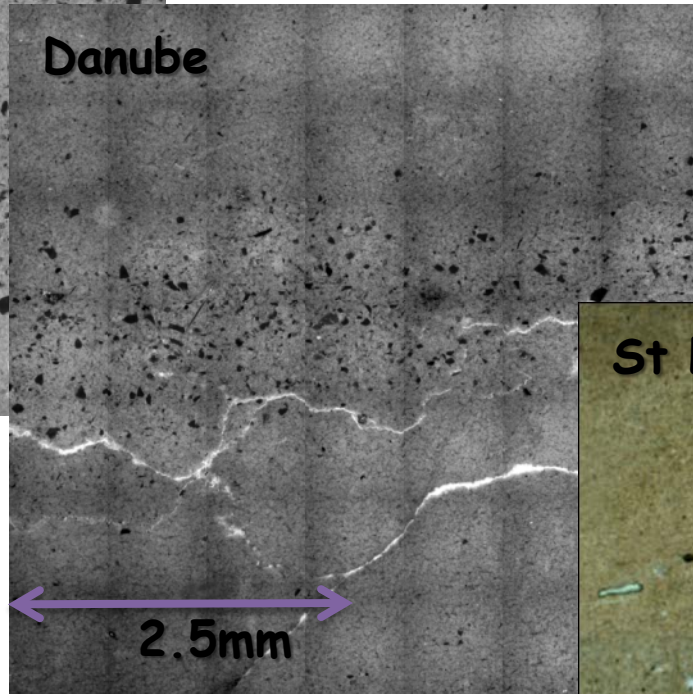
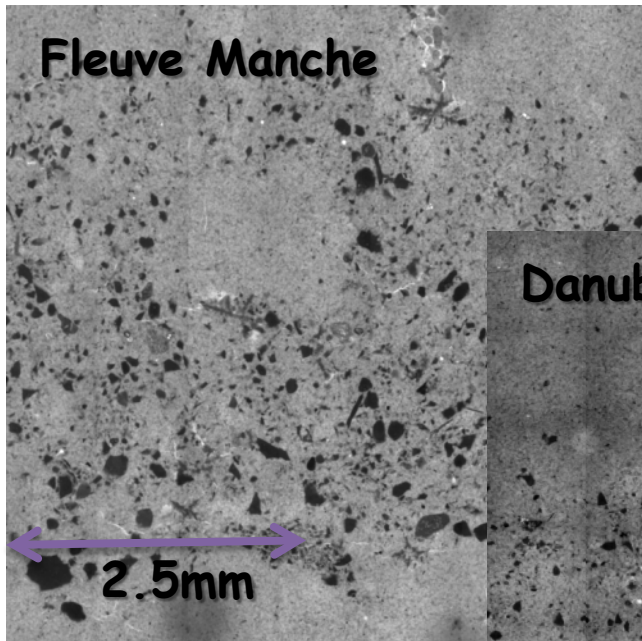
Natural light





Varves à IRD prélevée dans la rivière aux vaches (Canada - Québec) à proximité de l'estuaire du Saint-Laurent.





## Débâcle printanière du St Laurent (Canada, mai 2014)



## Débâcle printanière du St Laurent (Canada, mai 2014)



## Débâcle printanière du St Laurent (Canada, mai 2014)

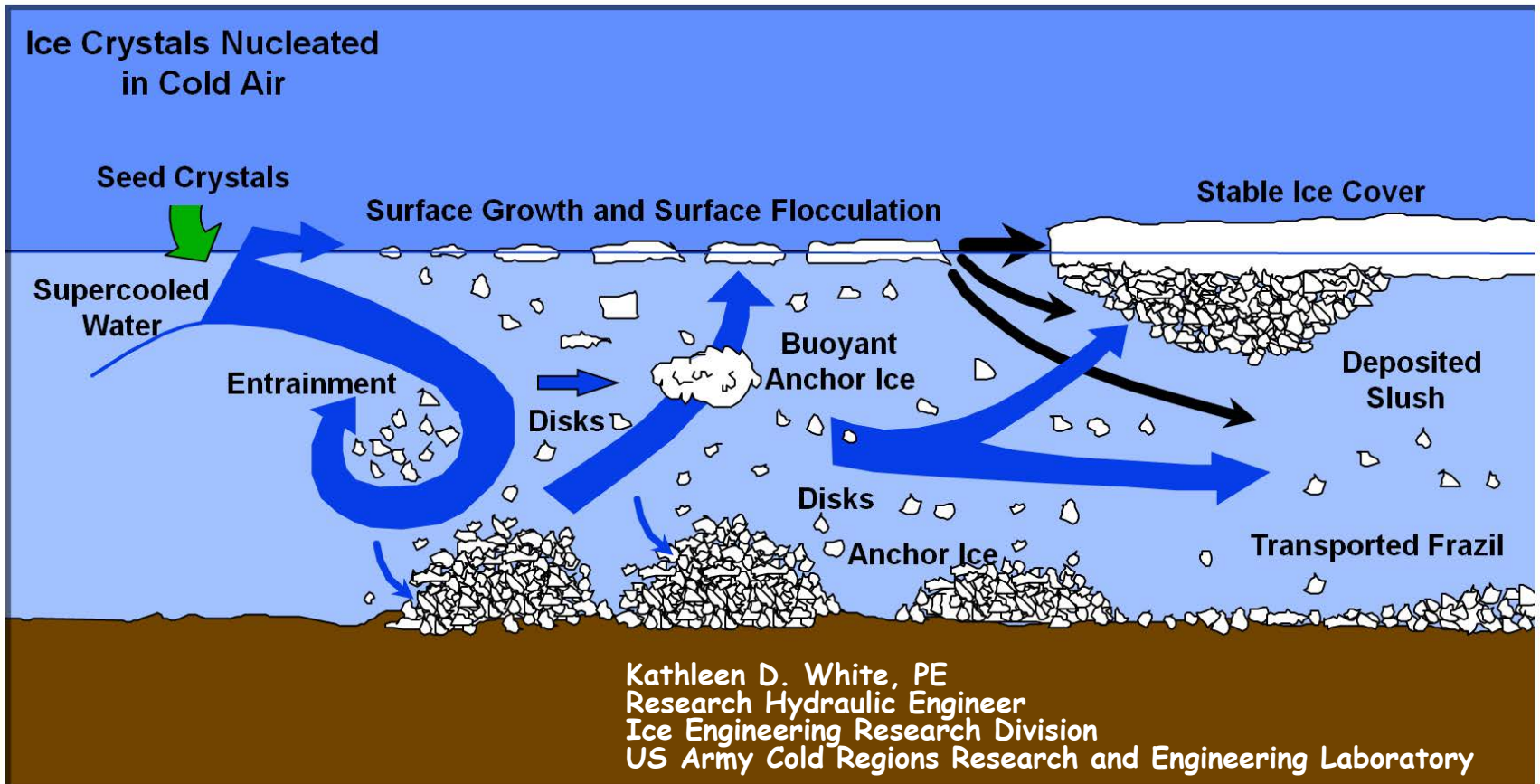


## Débâcle printanière du St Laurent (Canada, mai 2014)



## Débâcle printanière du St Laurent (Canada, mai 2014)





# Processus d'incorporation de sédiments dans la glace

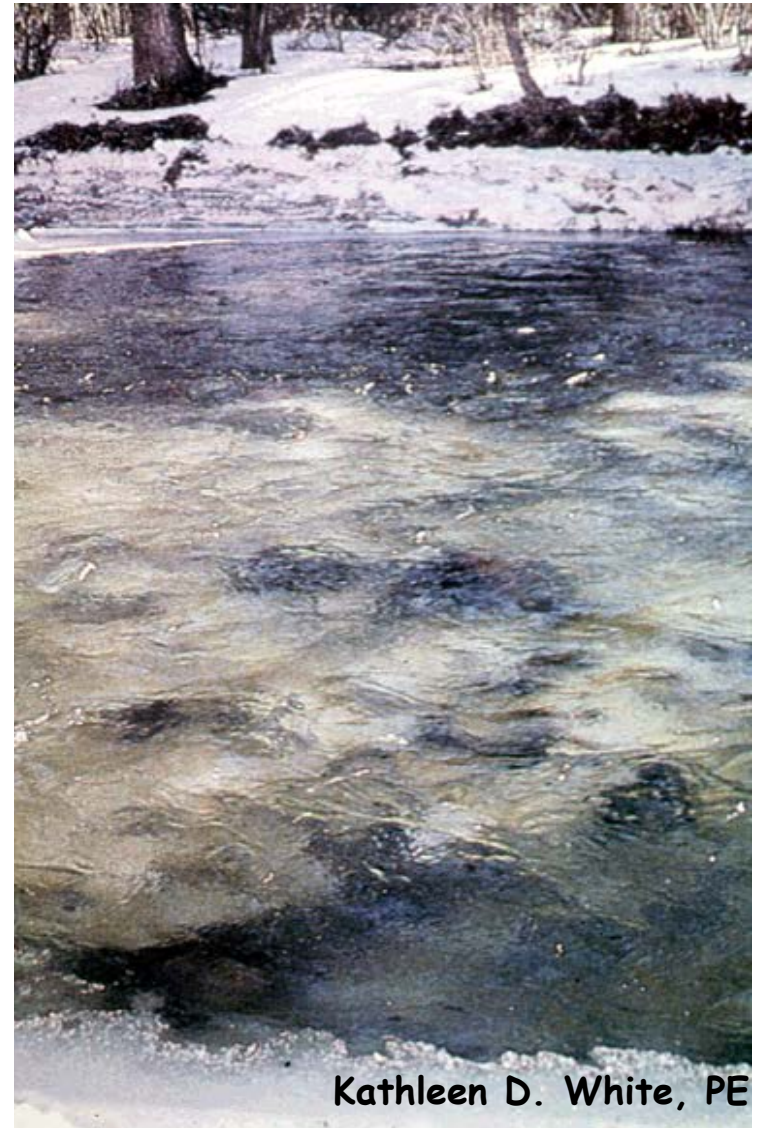
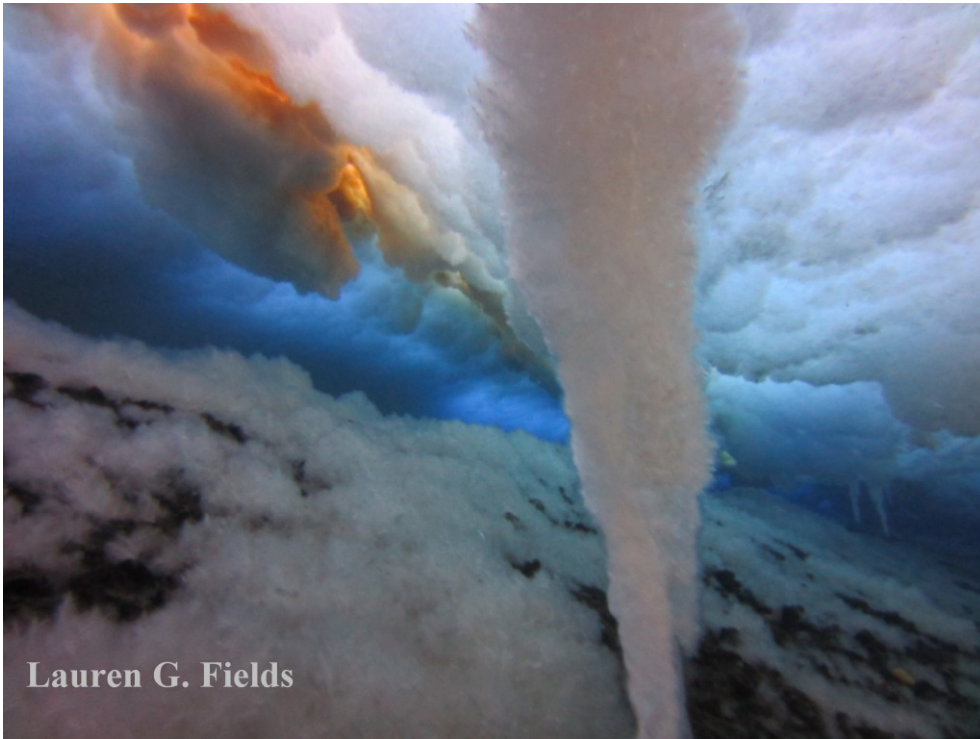
*Frazil ice* : Agrégation de cristaux de glace en formation



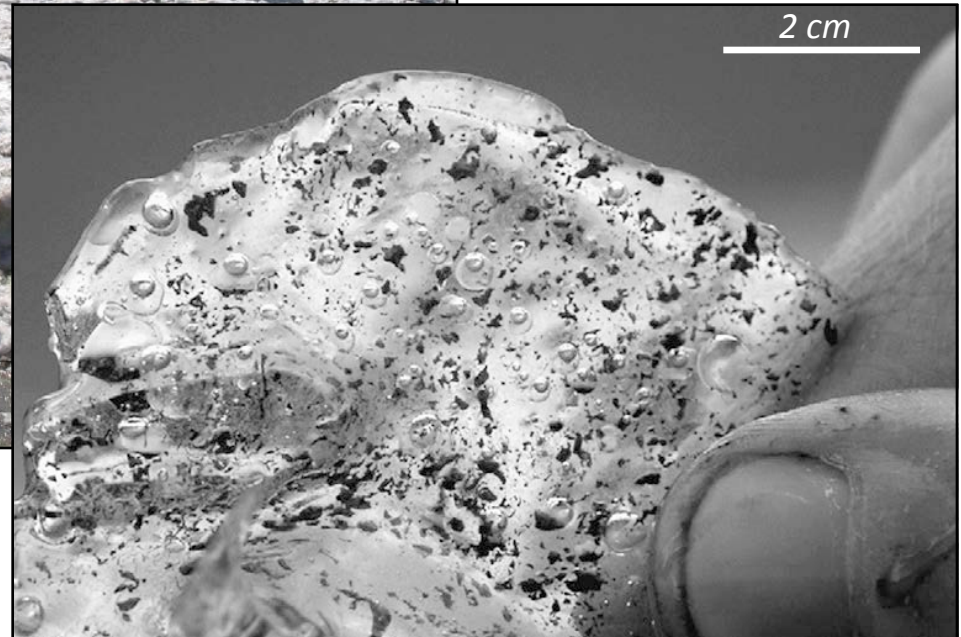
Kathleen D. White, PE

# Processus d'incorporation de sédiments dans la glace

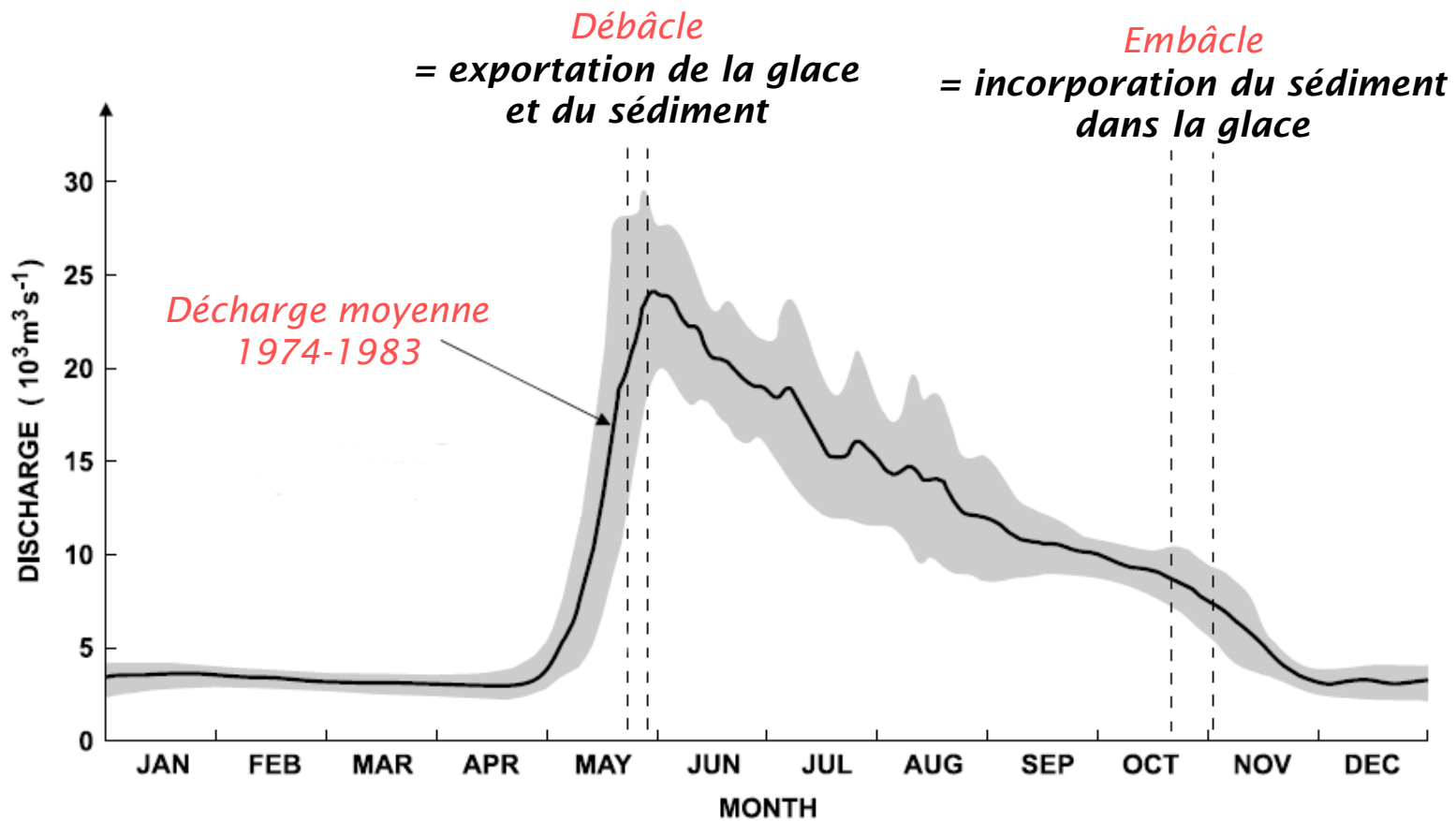
*Anchor Ice* : les cristaux de glace s'ancrent sur le fond (rivière et plateau continental)



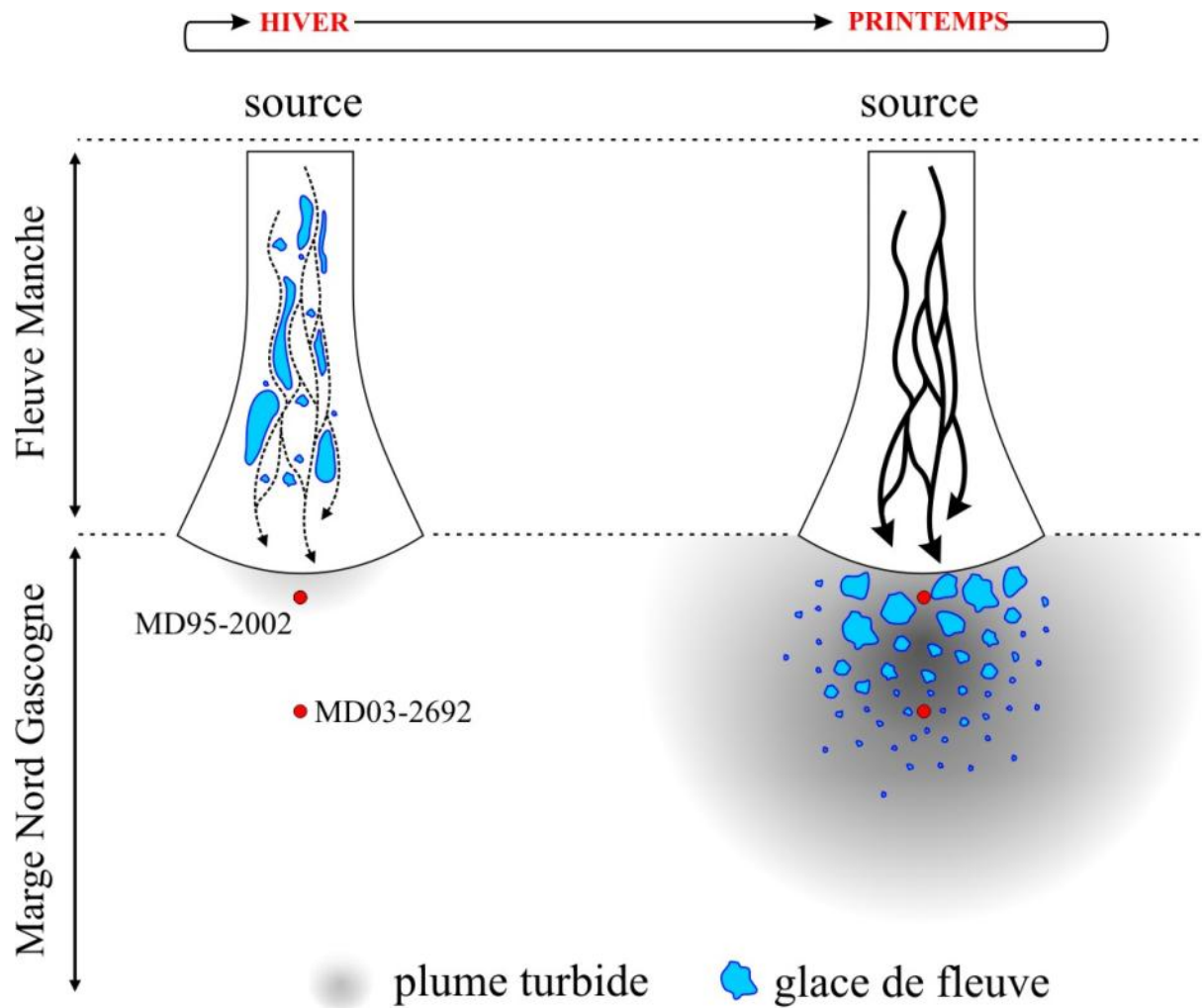
***Débâcle printanière du Fleuve McKenzie (Canada, mai 2004)***



***Exportation actuelle conséquente :***  
*5 à 8.10<sup>6</sup> t.an<sup>-1</sup> sur le plateau*  
*continental de la Mer de Beaufort*  
*(Eicken et al., 2007)*



Hill et al., 2001



**Modèle de mise en place du faciès laminé entre 18,3 et 17 ka**

(Toucanne et al., Quaternary Science Reviews, 2010)



La Loire (1918)

75 NEVERS. — La Loire, Janvier 1918 - Vue prise de la Levée de Médine

The River Loire, January 1918. View taken from Medine Dike. — N. G

**La Loire (1956)**





**La Loire (1963)**

**HIVER 1963**

**La Loire (1985)**



*Embâcle de la Loire à Nantes en février 1985  
(crédit photo : B. Van Vliet-Lanoe)*

## *Embâcle de la Loire février 2012*



*=> Fréquence 10 à 30 ans*

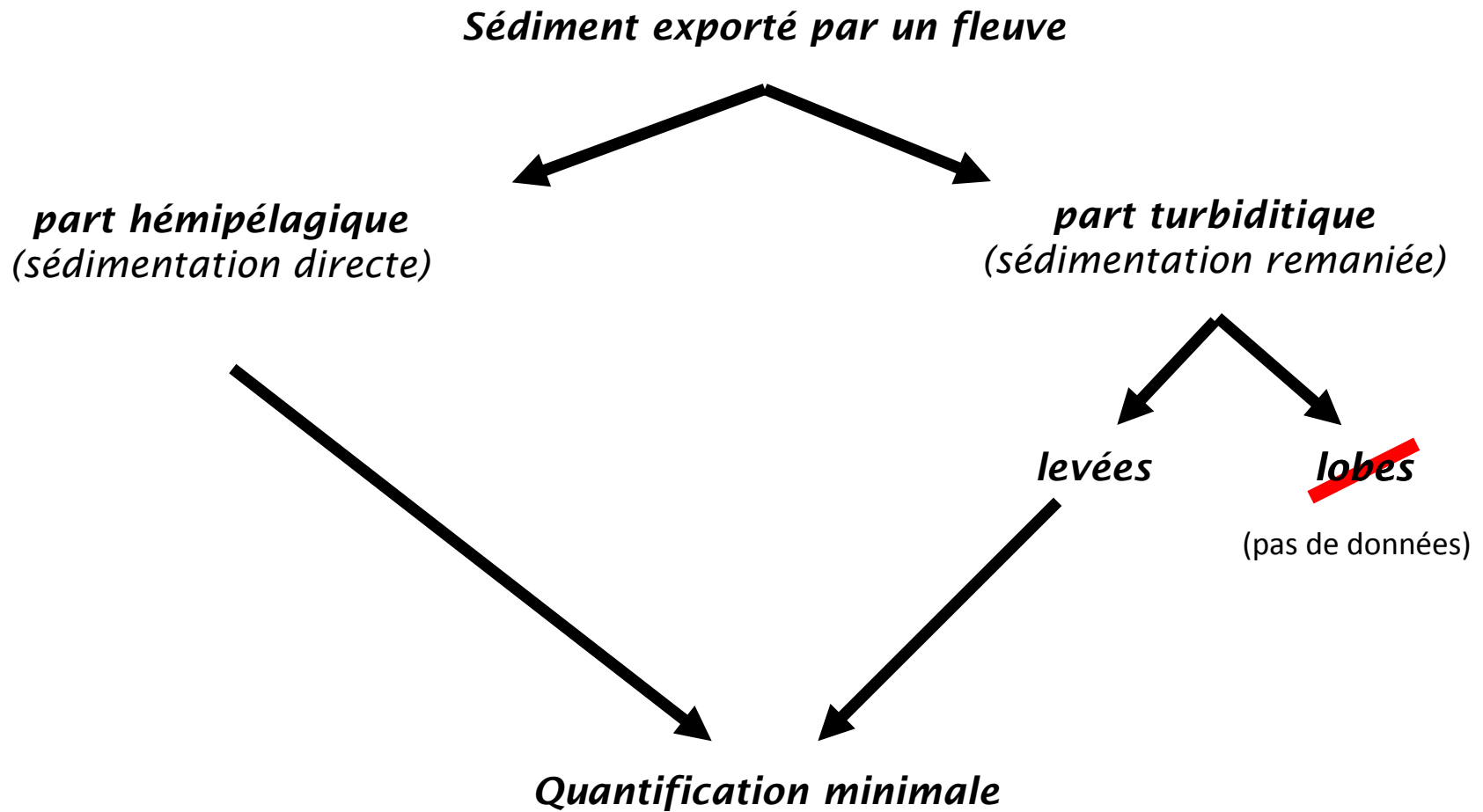
# L'histoire des fleuves passés

Comment étudier un fleuve ancien pas ses dépôts Profonds ?

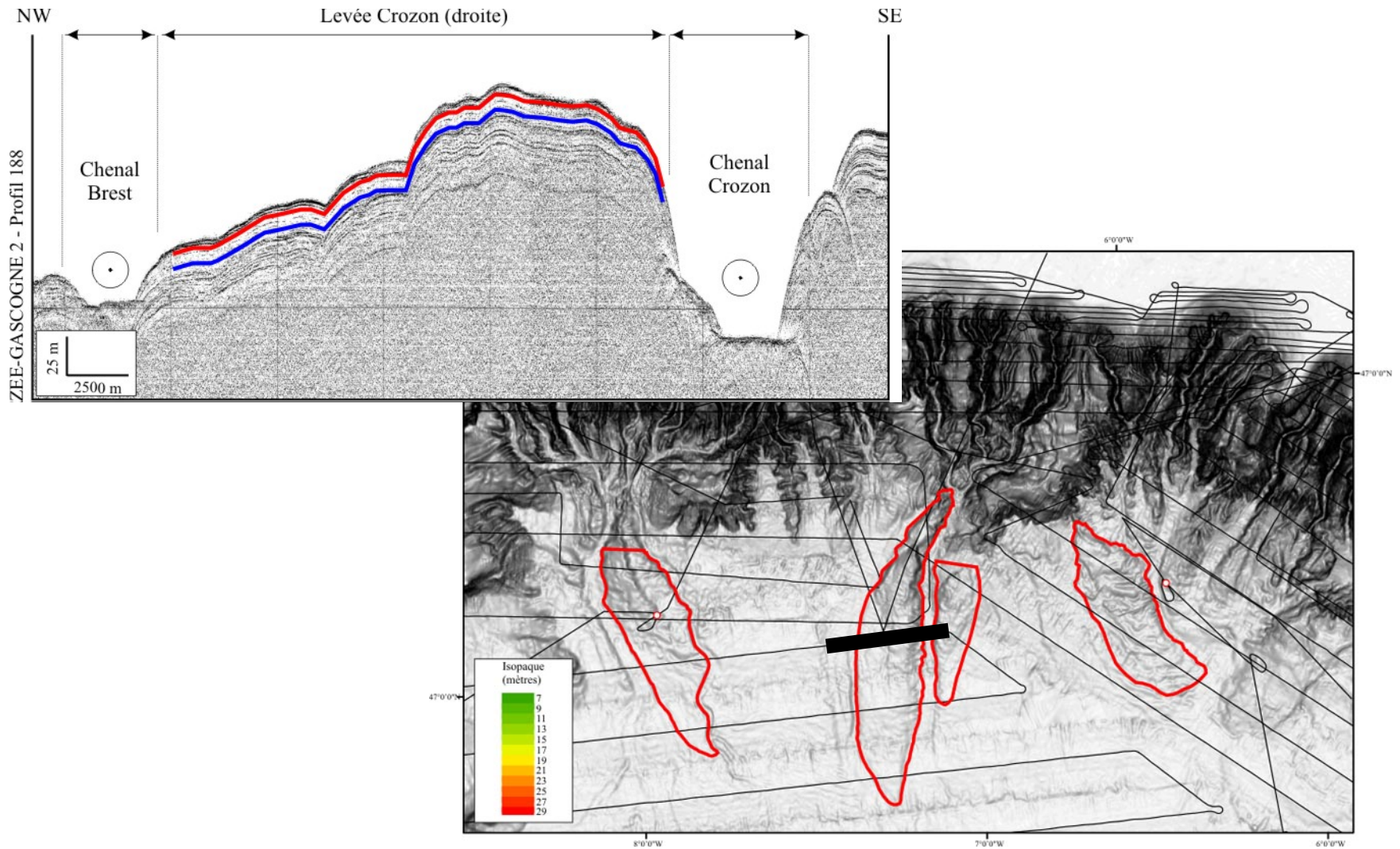
## L'Histoire du Fleuve Manche

- ➔ Quelle a été sa période d'activité ?
- ➔ Quel était son régime hydrologique ?
- ➔ **Peux-t-on estimer son débit solide ?**
- ➔ Quelle a été l'extension de son bassin versant ?

# Quantification du débit solide du Fleuve Manche entre 24 et 16 ka BP.

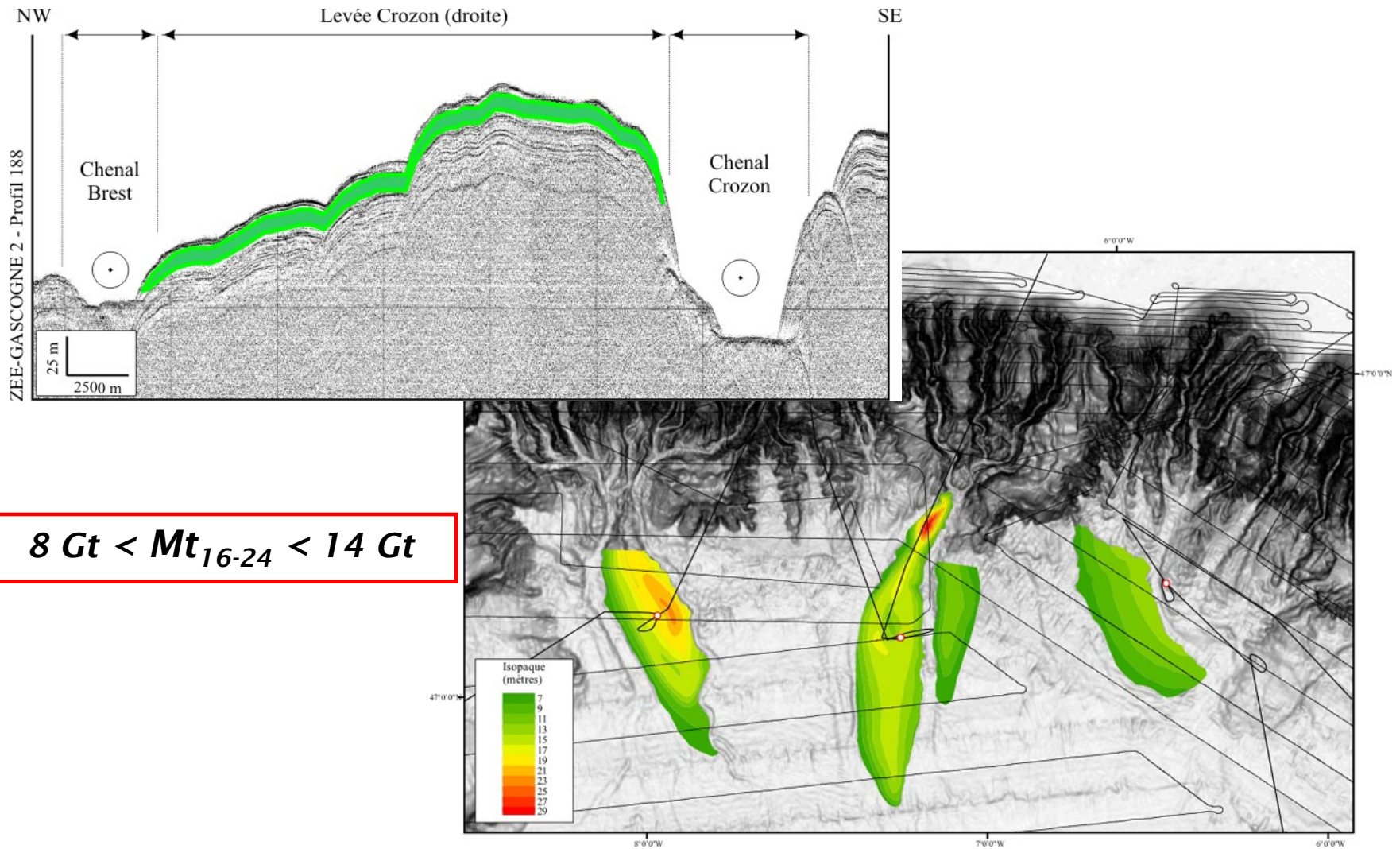


# Estimation de la masse déposée dans les levées turbiditiques : $M_t$



Toucanne et al 2010

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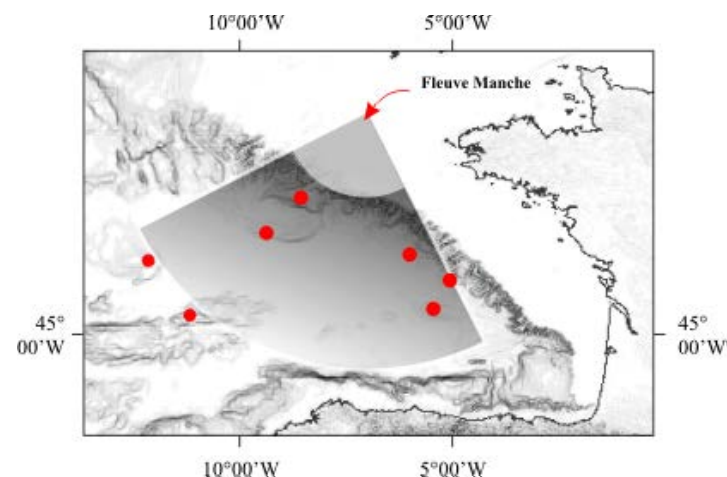
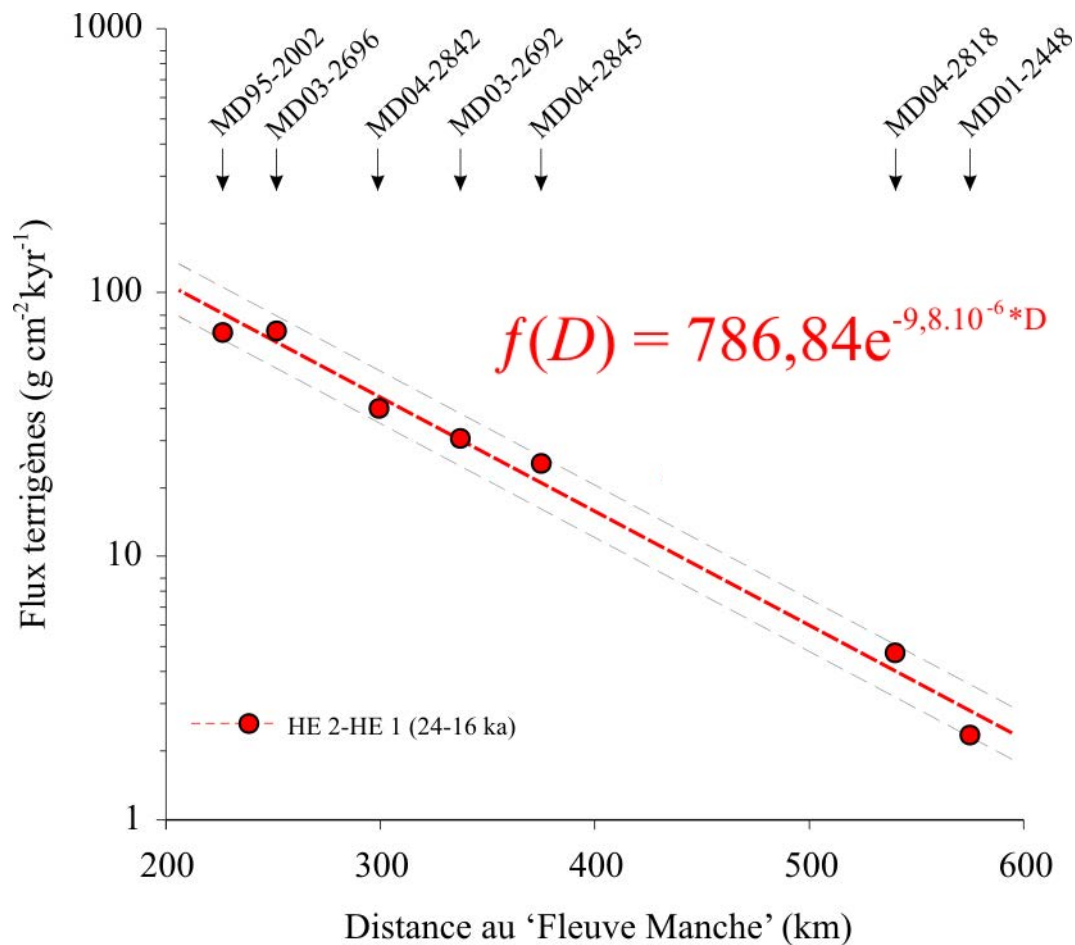


**$8 \text{ Gt} < M_{t16-24} < 14 \text{ Gt}$**

Toucanne et al 2010



## Estimation de la masse hémipélagique : $Mh_{16-24}$



$$414 \text{ Gt} < Mh_{16-24} < 504 \text{ Gt}$$

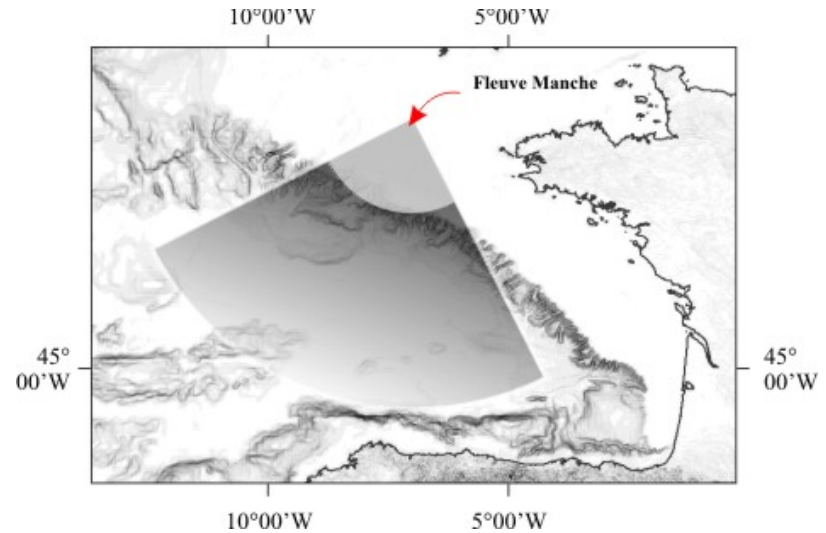
Toucanne et al 2010

## Estimation globale ( $Mh + Mt$ )

$$8 \text{ Gt} < Mt_{16-24} < 14 \text{ Gt}$$

$$414 \text{ Gt} < Mh_{16-24} < 504 \text{ Gt}$$

$$422 \text{ Gt} < M_{16-24} < 528 \text{ Gt}$$

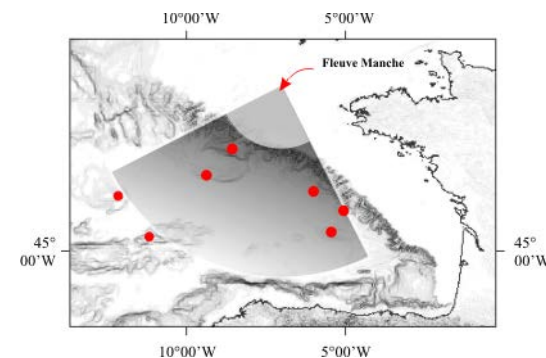
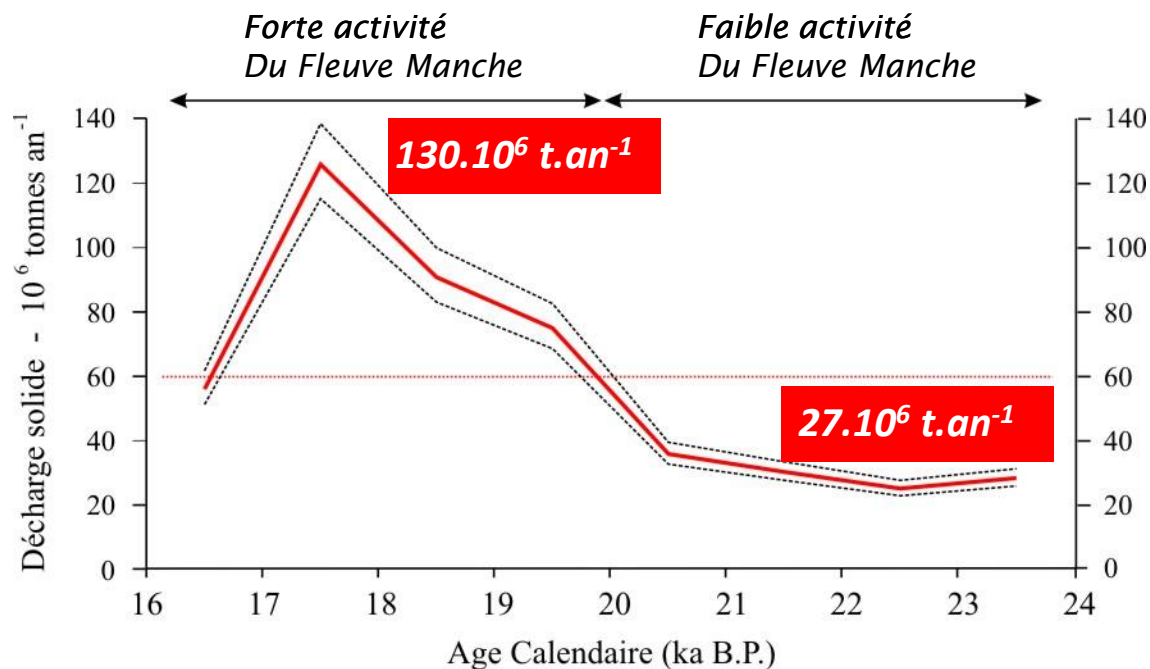


## Décharge solide ( $Ds$ )

$$56.10^6 \text{ t.an}^{-1} < Ds < 67.10^6 \text{ t.an}^{-1}$$

nb: Loire + Gironde + Vilaine + Charente + Adour =  $2.10^6 \text{ t.an}^{-1}$  (Jouanneau et al., 1999)

## Estimation globale (Mh + Mt)



Toucanne et al 2010

## Décharge solide (Ds)

$$56.10^6 \text{ t.an}^{-1} < Ds < 67.10^6 \text{ t.an}^{-1}$$

nb: Loire + Gironde + Vilaine + Charente + Adour =  $2.10^6 \text{ t.an}^{-1}$  (Jouanneau et al., 1999)

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- ➔ **Quelle a été l'extension de son bassin versant ?**

# Relation Surface des bassins versants / débits solides

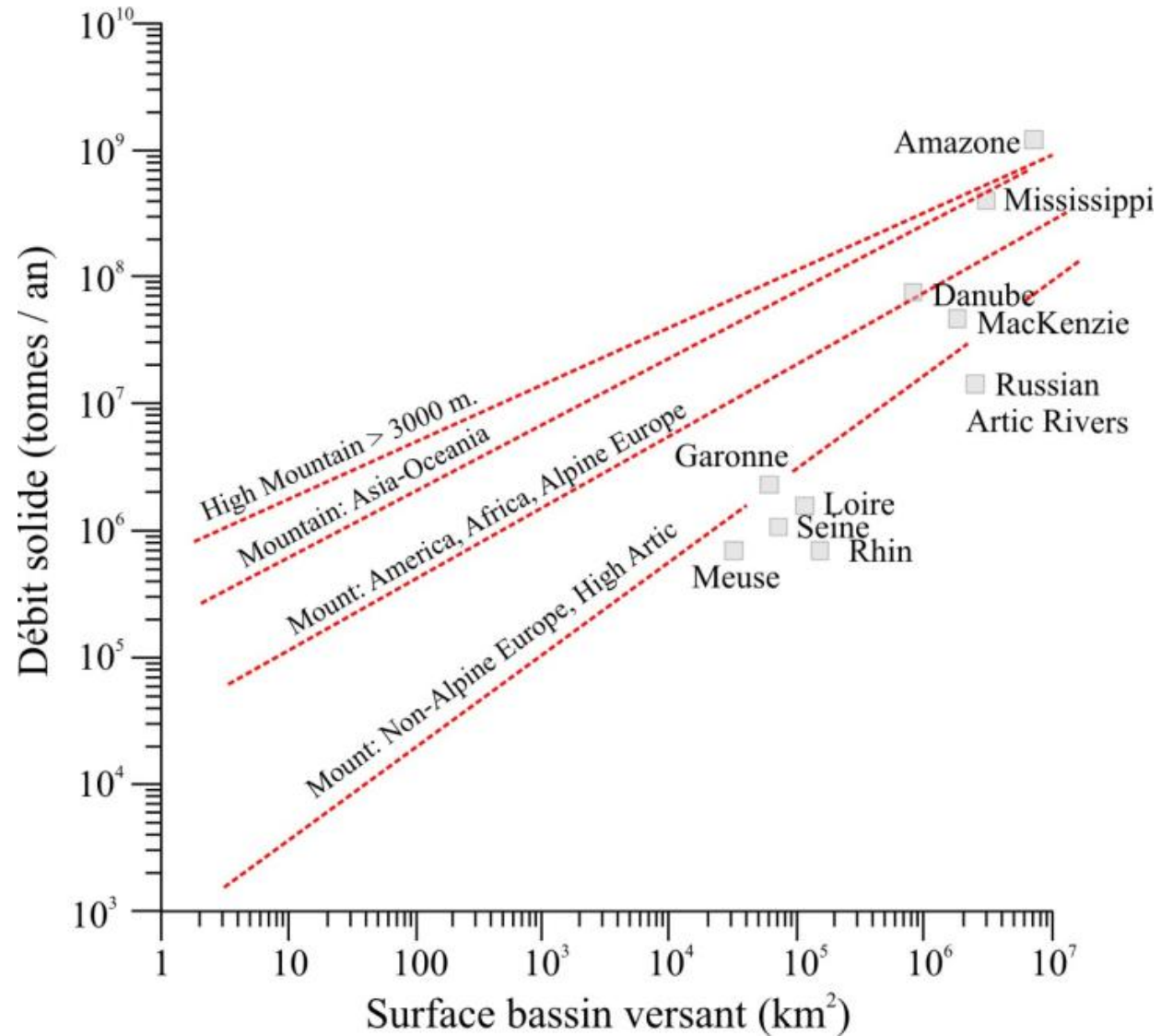
$$\text{Débit solide} = f(A, R, T)$$

*A* : surface du bassin versant

*R* : altitude max. du BV

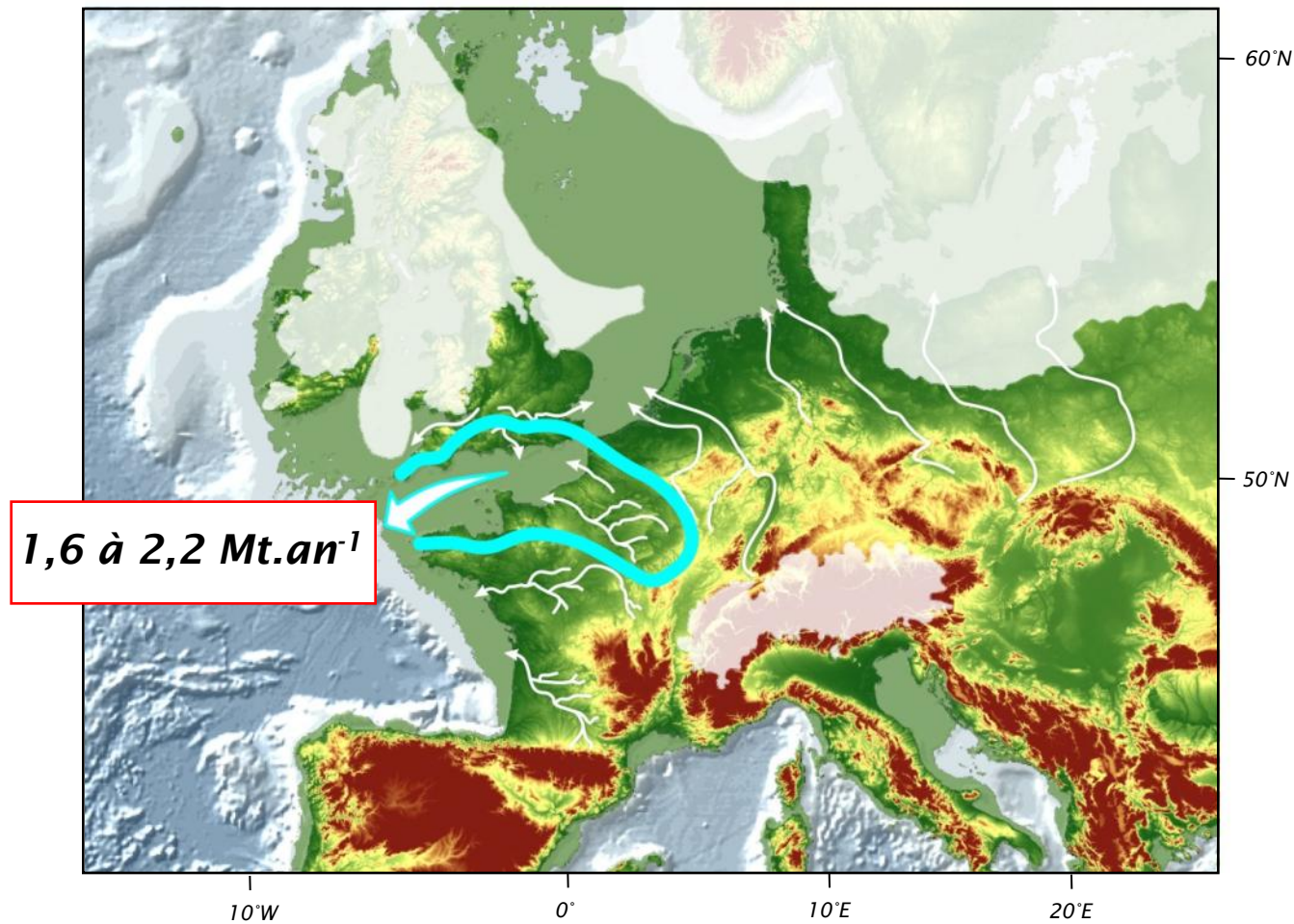
*T* : *T* annuelles moyennes

*Syvitski et al., 2003*



Milliman and Syvitski, 1992

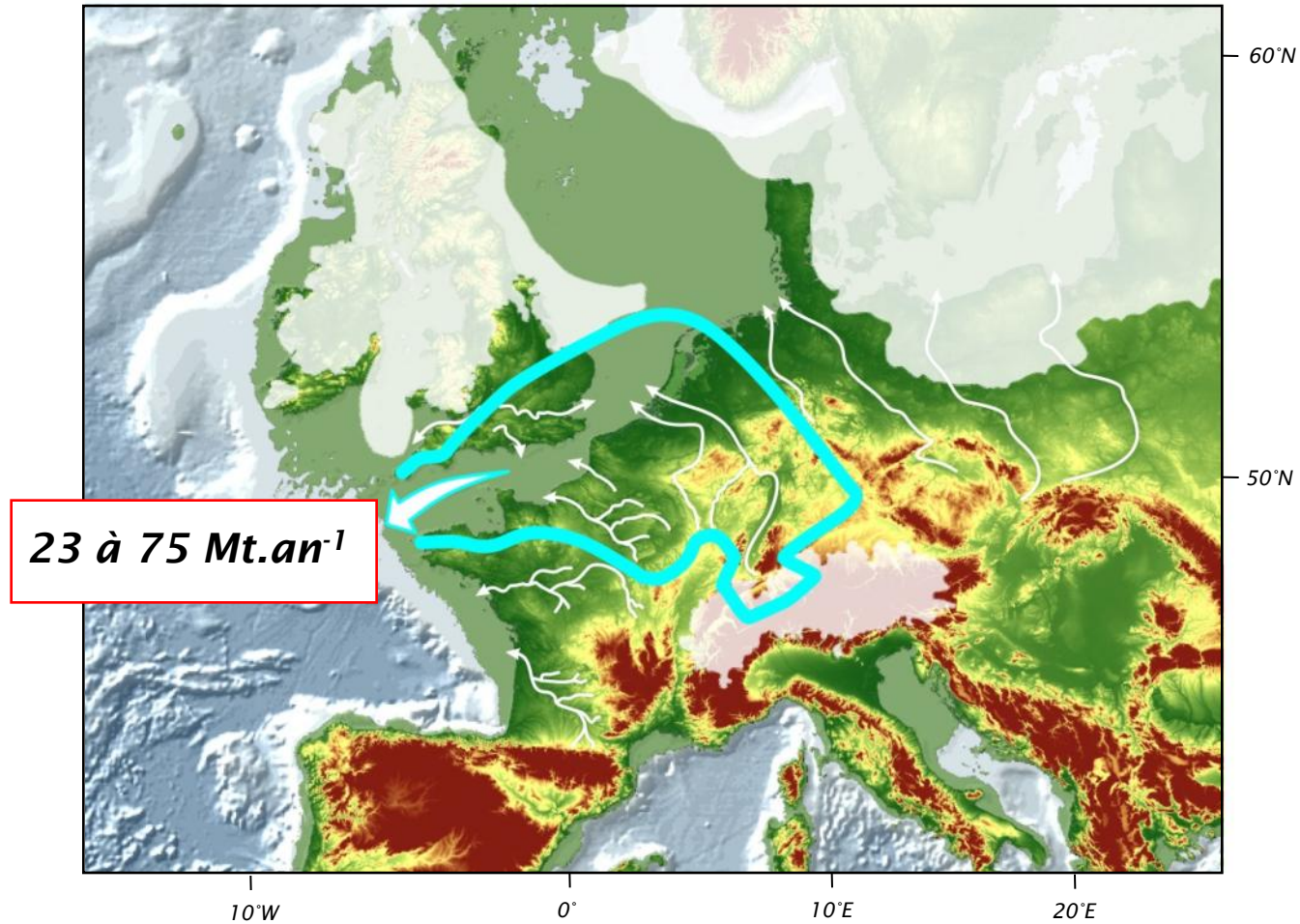
## Relation Surface des bassins versants / débits solides



*Cas 1 : Fleuve Manche restreint au Bassin Parisien et Londonien*

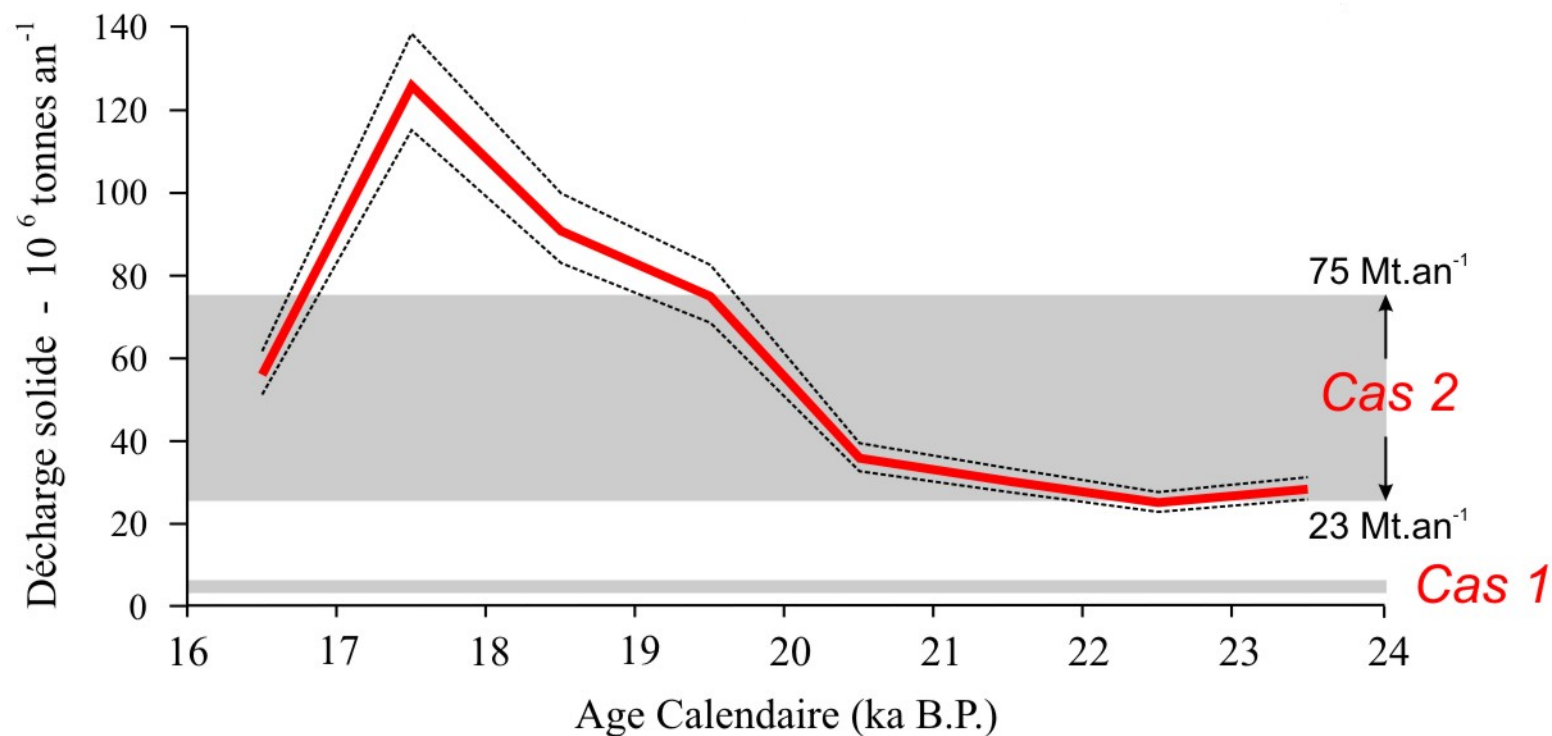
*Surface = ~300 000 km<sup>2</sup> ; Elévation max. 450 m.*

## Relation Surface des bassins versants / débits solides



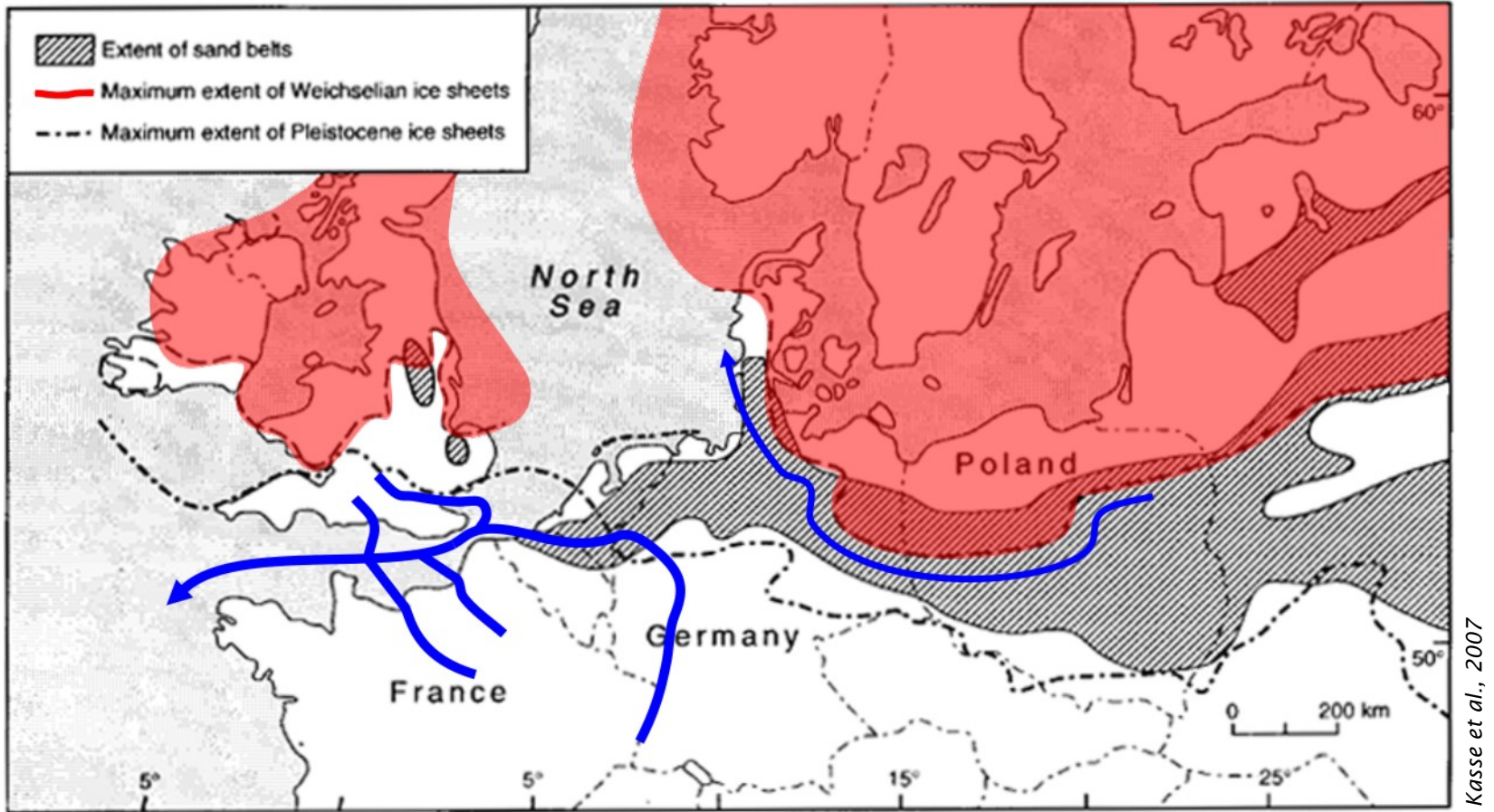
*Cas 2 : Cas 1 + Rhin + Sud Mer du Nord*  
*Surface = ~750 000 km<sup>2</sup> ; Elévation max. 3500 m.*

## Relation Surface des bassins versants / débits solides

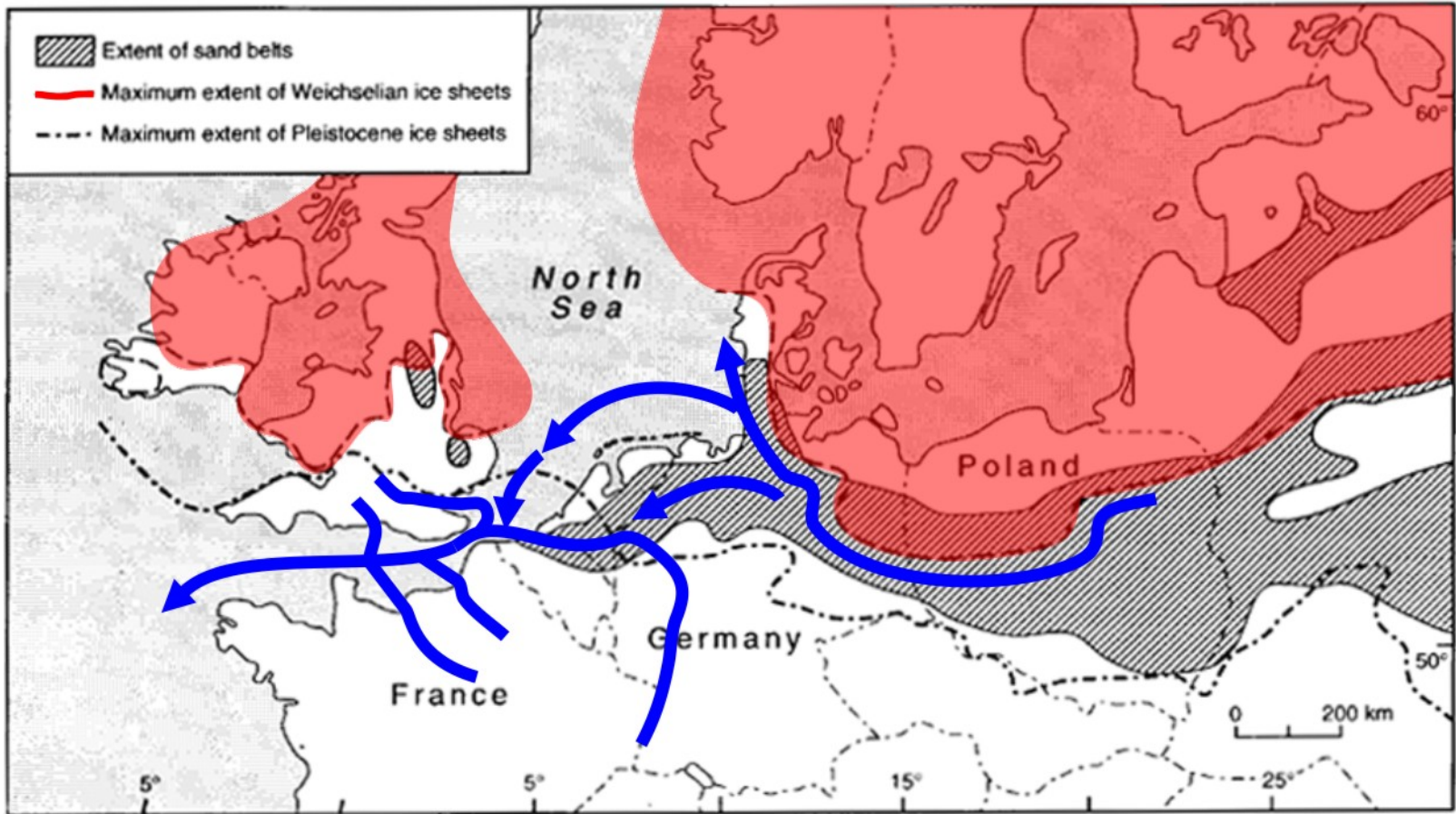


*Surface du Bassin-versant du Fleuve Manche >> Cas 2 (750.000km<sup>2</sup>)...*

# Implications paléogéographiques



# Implications paléogéographiques



Kasse et al., 2007

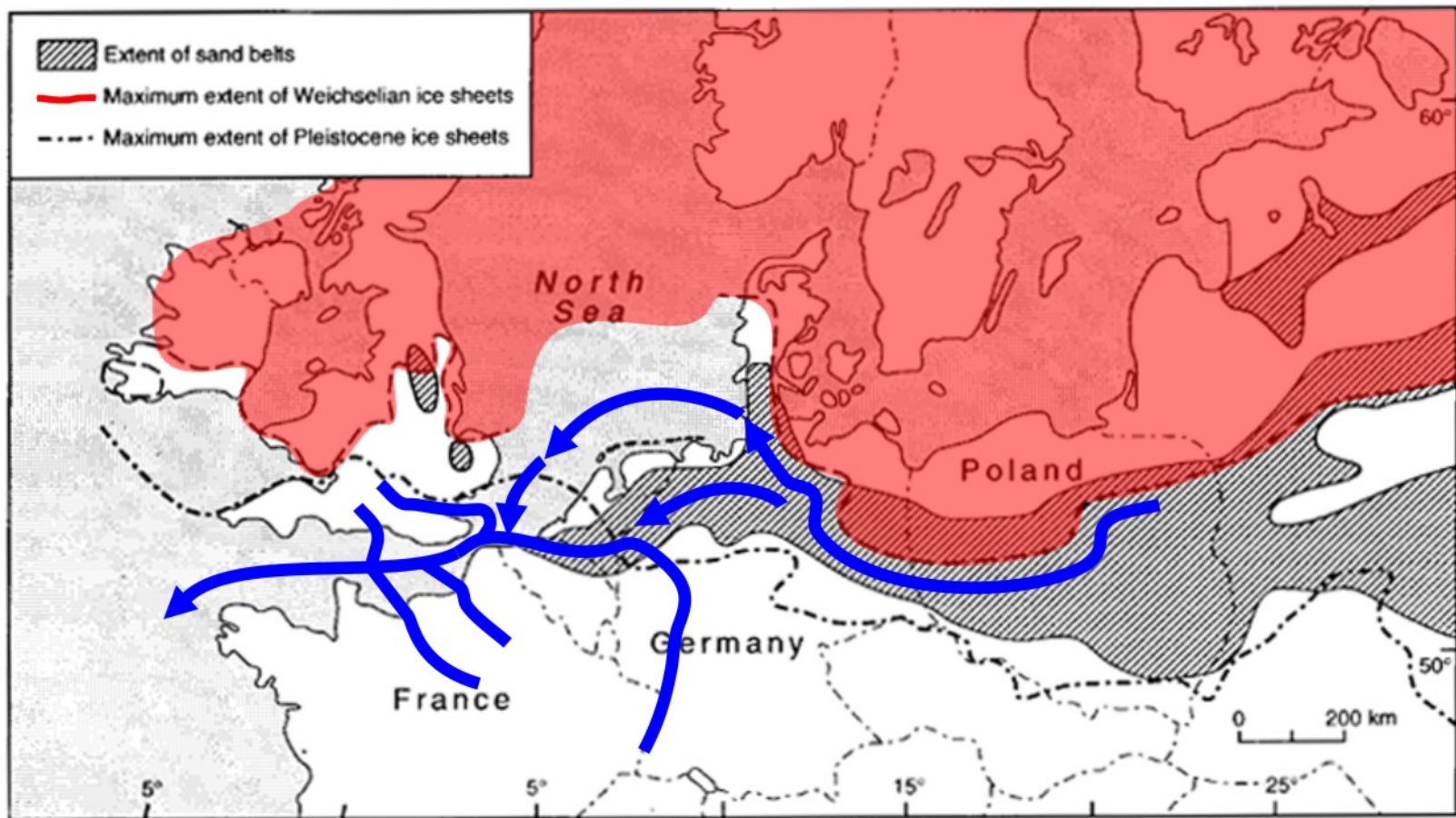
*Fleuve Manche connecté au réseau de drainage marginal d'Europe Centrale*

*Bassin versant : 1,2 millions km<sup>2</sup>*

**FORCAGE ?**

Toucanne et al 2009

# Implications paléogéographiques



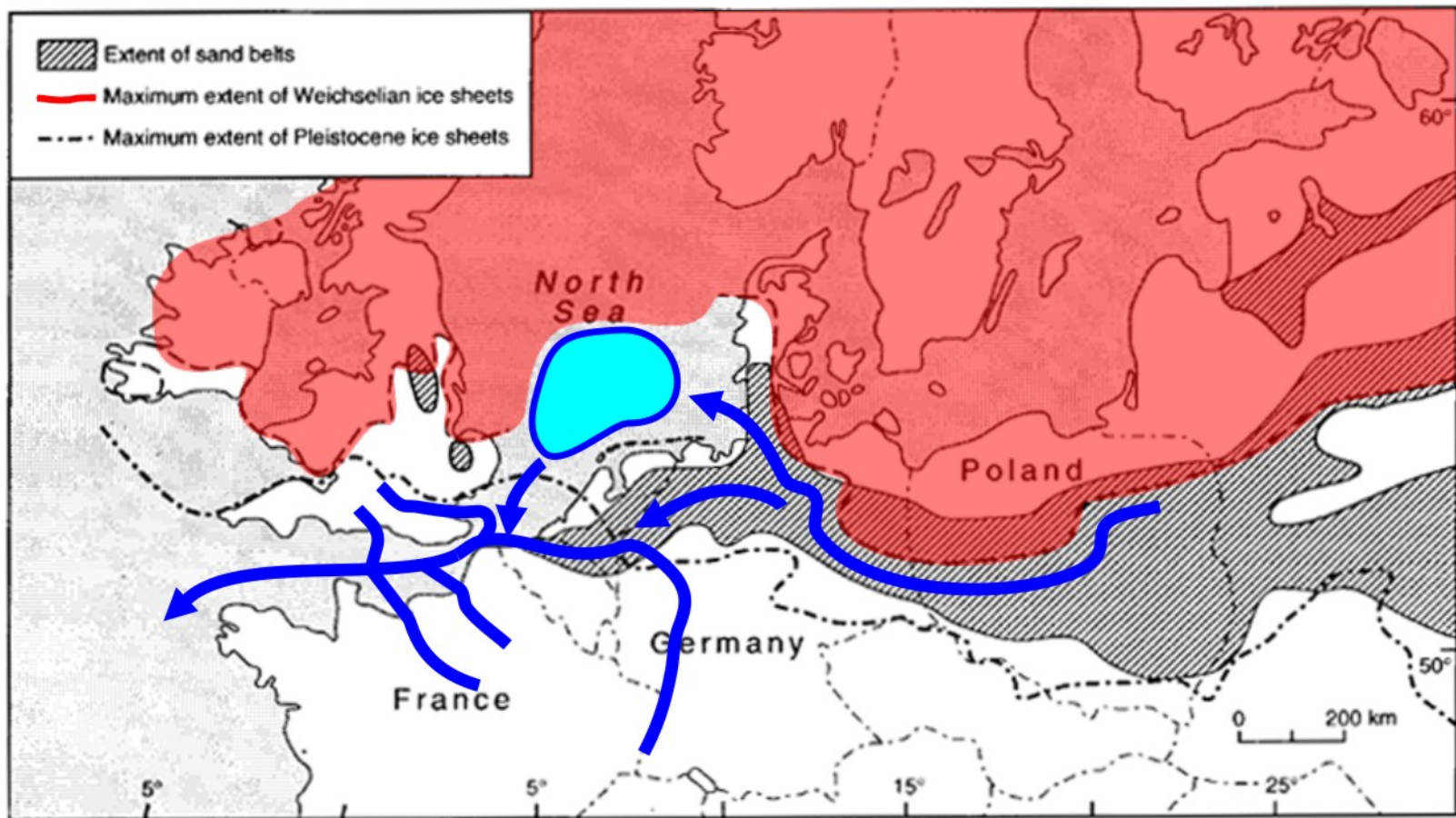
*Fleuve Manche connecté au réseau de drainage marginal d'Europe Centrale*

*Bassin versant : 1,2 millions km<sup>2</sup>*

**FORCAGE : MER DU NORD ENGLACE**

Toucanne et al 2009

# Implications paléogéographiques



Kasse et al., 2007

*Fleuve Manche connecté au réseau de drainage marginal d'Europe Centrale*

*Bassin versant : 1,2 millions km<sup>2</sup>*

**FORCAGE : MER DU NORD ENGLACE + LAC PROGLACIAIRE**

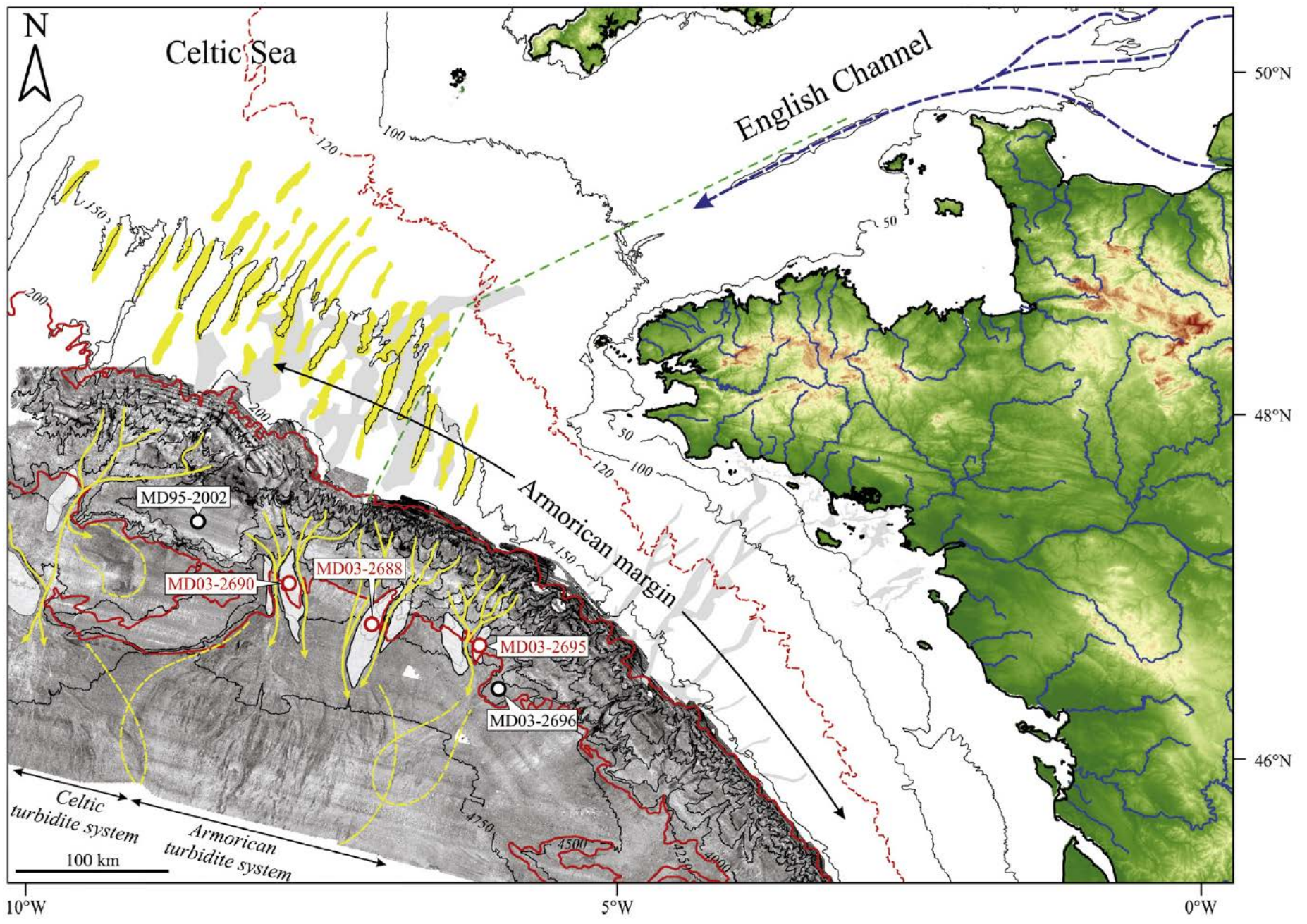
Toucanne et al 2009

# L'histoire des fleuves passés

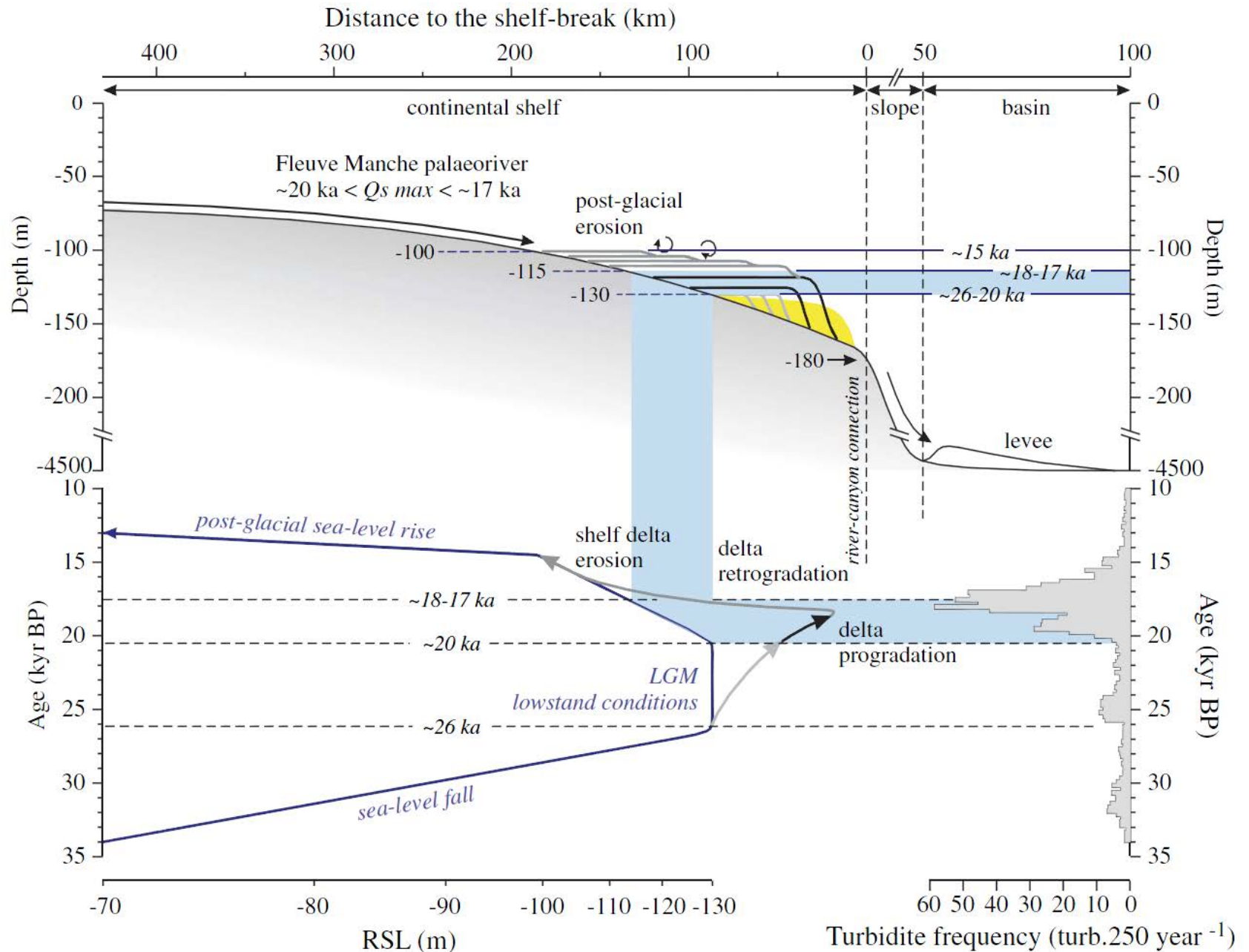
Comment étudier un fleuve ancien pas ses dépôts Profonds ?

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- ➔ Peux-t-on estimer son débit solide ?
- ➔ Quelle a été l'extension de son bassin versant ?
- ➔ **As-t'il formé un delta ?**



Toucanne et al. 2012



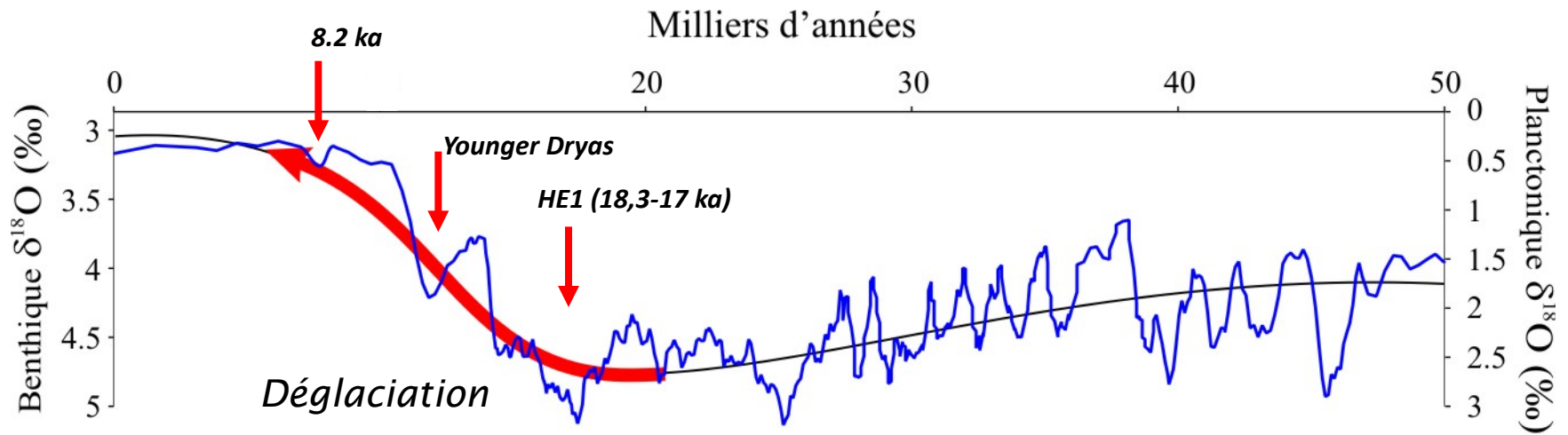
Toucanne et al. 2012

# L'histoire des fleuves passés

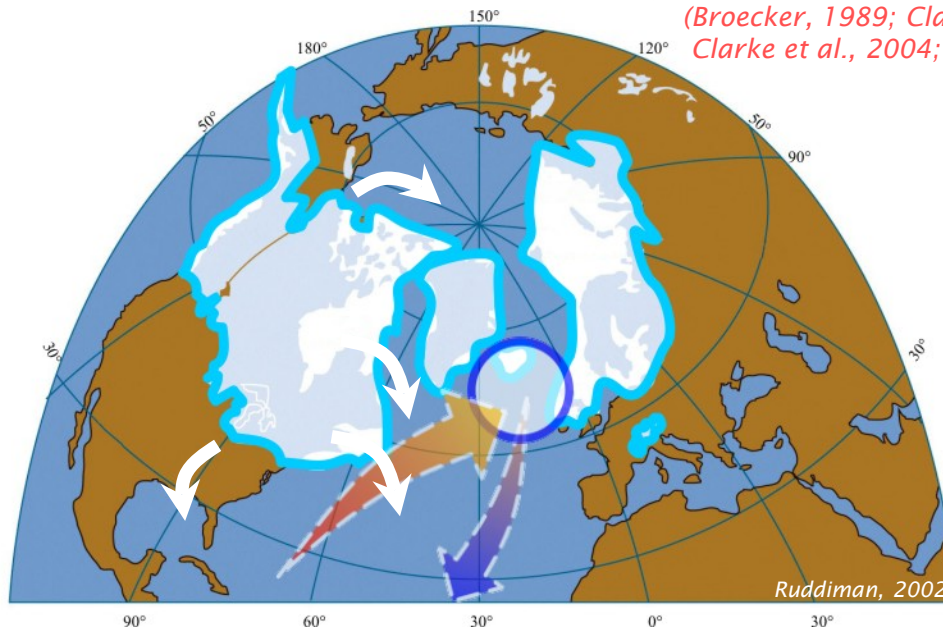
Comment étudier un fleuve ancien pas ses dépôts Profonds ?

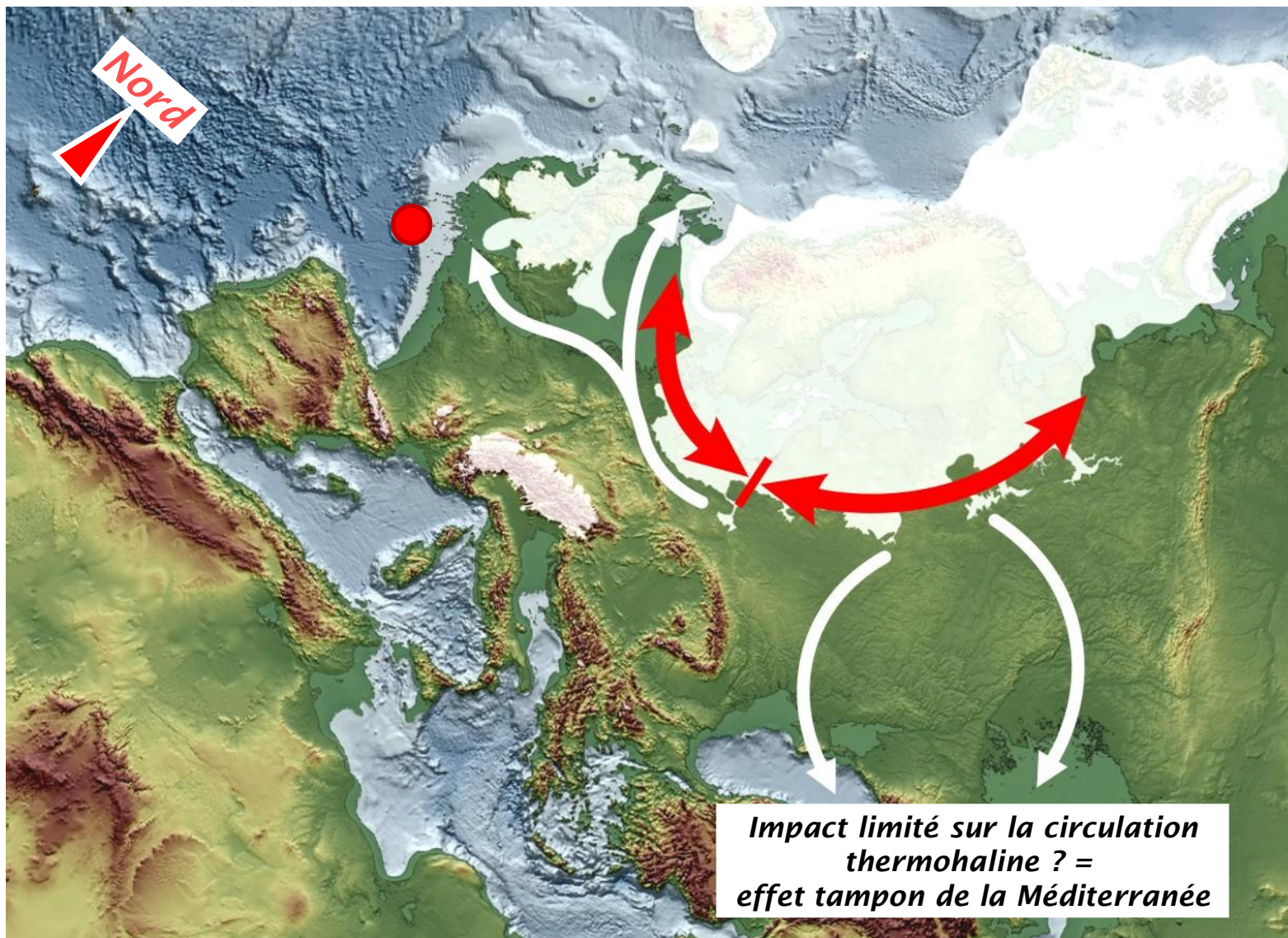
## L'Histoire du Fleuve Manche

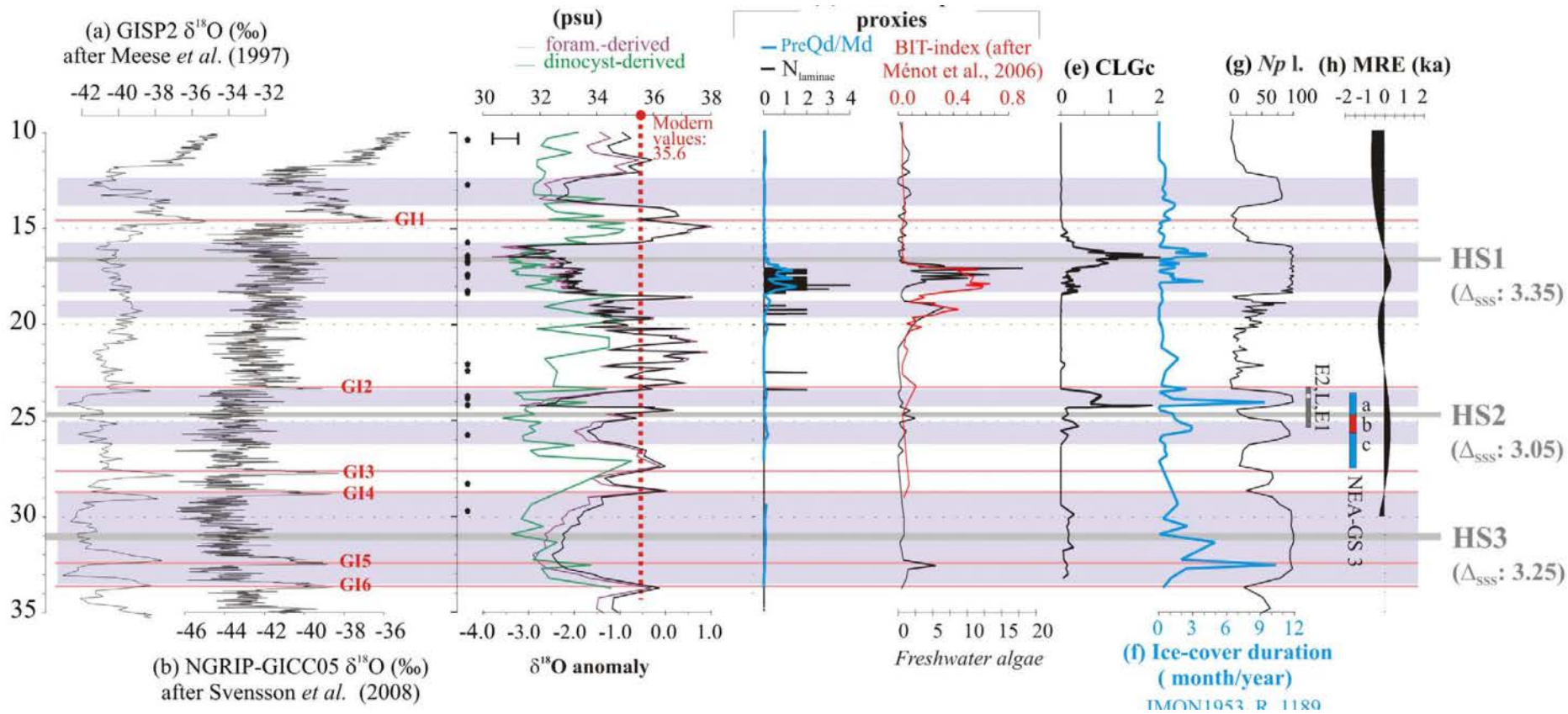
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- ➔ Quelle a été l'extension de son bassin versant ?
- ➔ As-t'il formé un delta ?
- ➔ **Quel peut être l'impact de sa mise en place sur le climat ?**



**➔ Décharges massives d'eau douces dans l'Atlantique Nord**  
*(Broecker, 1989; Clark et al., 1999, 2001; Clarke et al., 2004; etc.)*

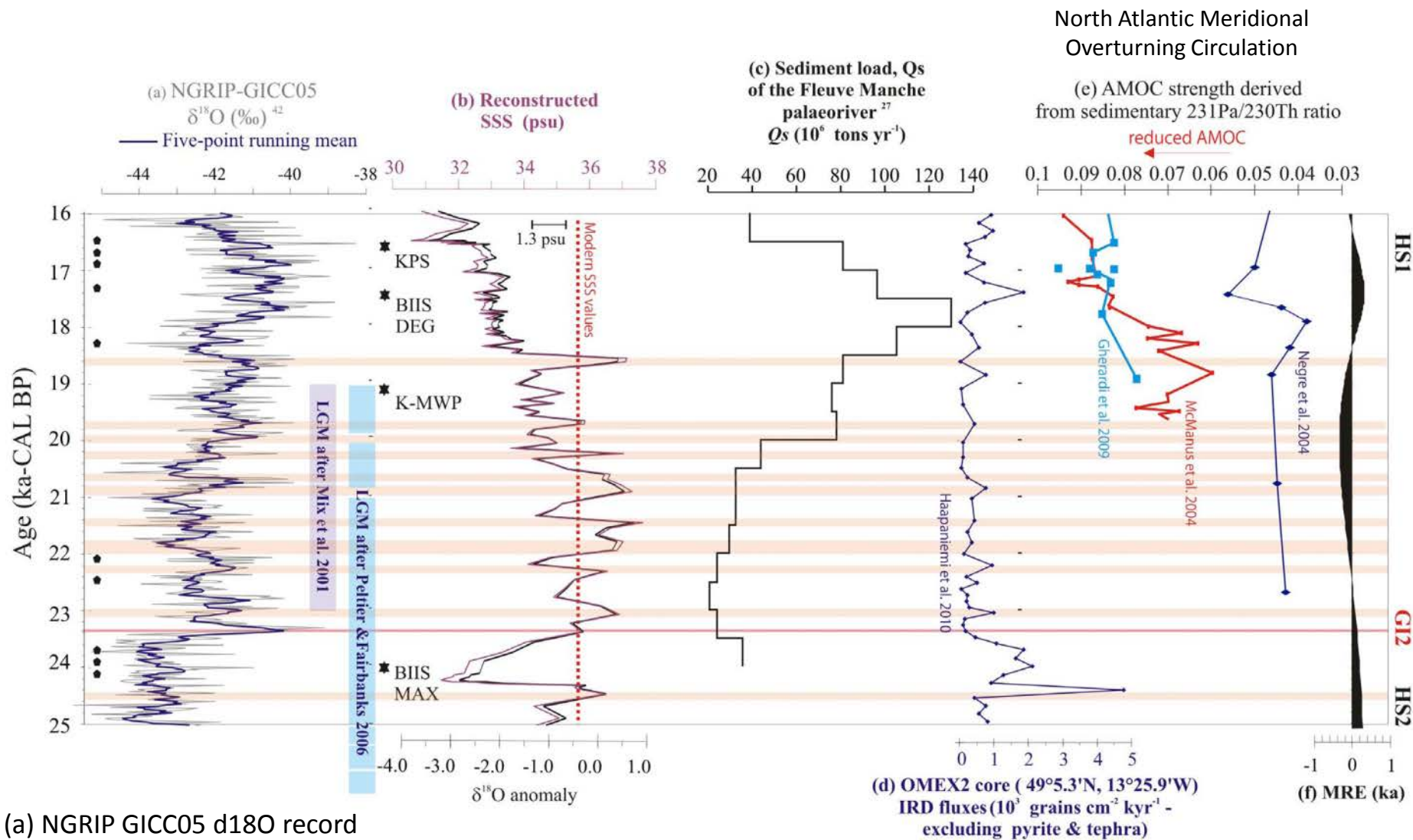






Eynaud et al. 2012

- (a) GISP2 and (b) NGRIP GICC05 d18O records
  - (c) SSS reconstructions derived from d18O/ planktonic foraminifera data and from dinocysts
  - (d) fluvial input proxies including: PreQd/Md, the ratio of Pre-Quaternary versus Modern dinocysts N<sub>laminae</sub>, the number of laminae per cm of sediment; the branched and isoprenoid tetraether (BIT)-index data; the freshwater algae *Pediastrum* sp. concentration in the sediment
  - (e) CLGc: coarse lithic grain concentrations
  - (f) the dinocyst derived sea- ice-cover duration
  - (g) relative abundances of *Neogloboquadrina pachyderma* left coiled (Npl.)
  - (h) MRE, estimation of the marine reservoir age effect over the MD95-2002 site
- Purple bands: periods for which both dinocyst and foraminifera derived SSS converge to indicate a SSS anomaly  
 Red lines: Greenland interstadial (GI) warmings



- (a) NGRIP GICC05 d18O record
- (b) foraminifera-derived SSS in the Bay of Biscay
- (c, d) European ice-sheet dynamics
- (e) AMOC strength derived from sedimentary  $^{231}\text{Pa}/^{230}\text{Th}$  ratio in the Atlantic sediment cores
- (f) MRE, estimation of the marine reservoir age effect over the MD95-2002 site.

Eynaud et al. 2012

