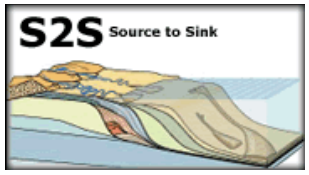
The continental slope as a pathway and sink for terrigenous sediment: an overview

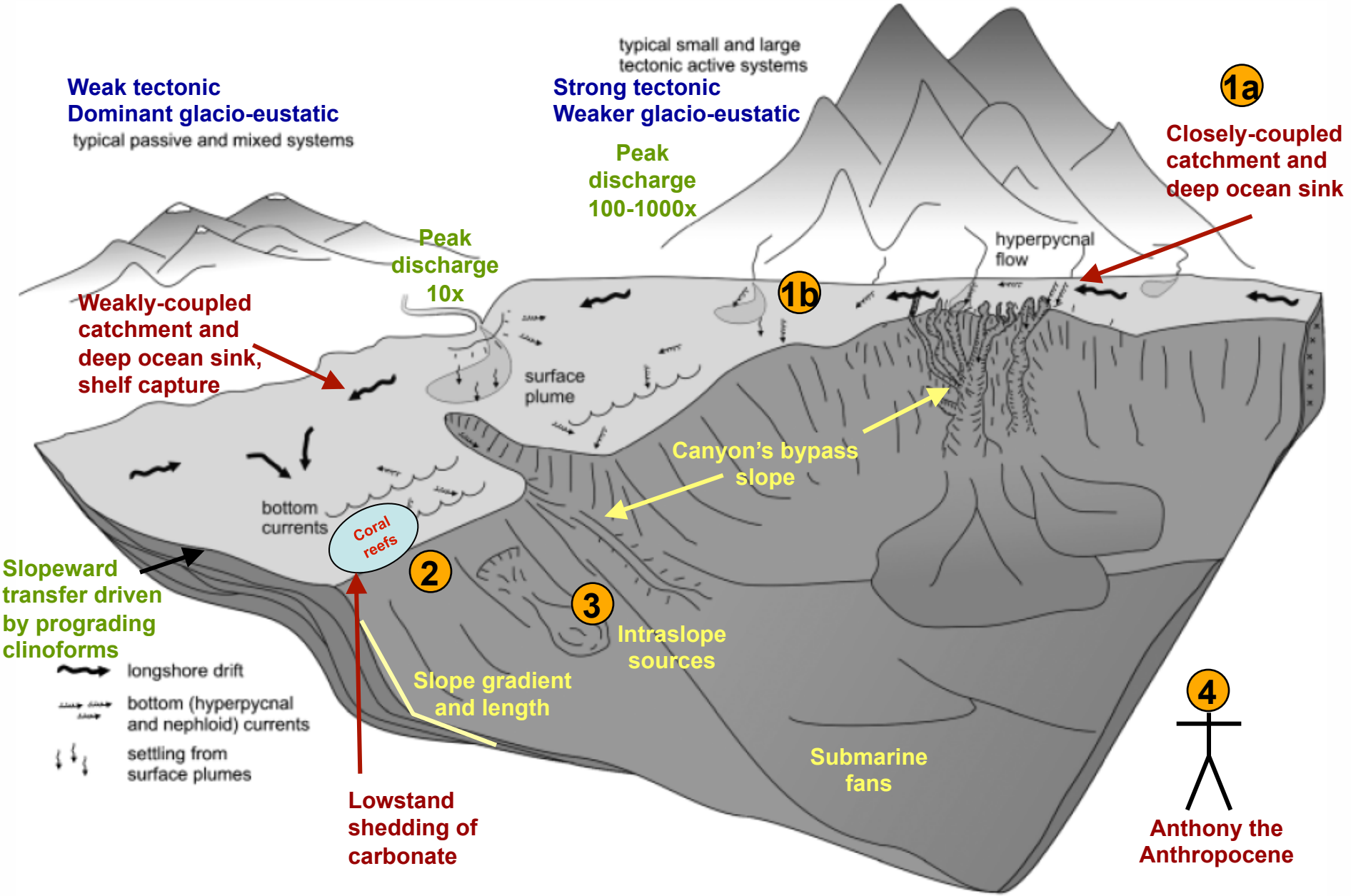
Recent evidence from Source-to-sink studies of contrasting sedimentation since the last glacial

Alan Orpin, Clark Alexander, J.P. Walsh, Steve Kuehl & Lionel Carter



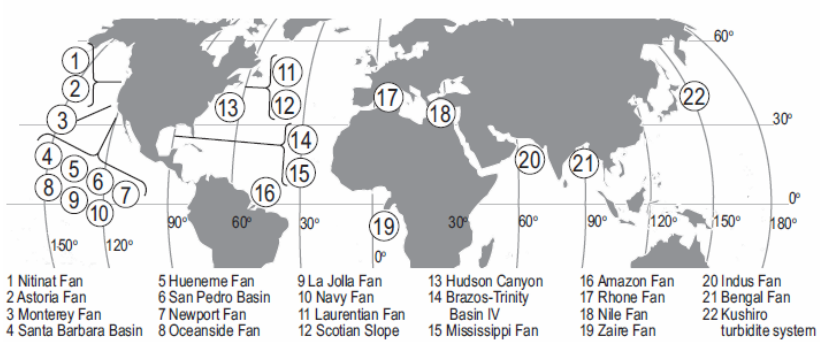
T. O. Sømme et al.

The slope system: a Gods-eye view



(Figure modified after Sømme et al., 2009)

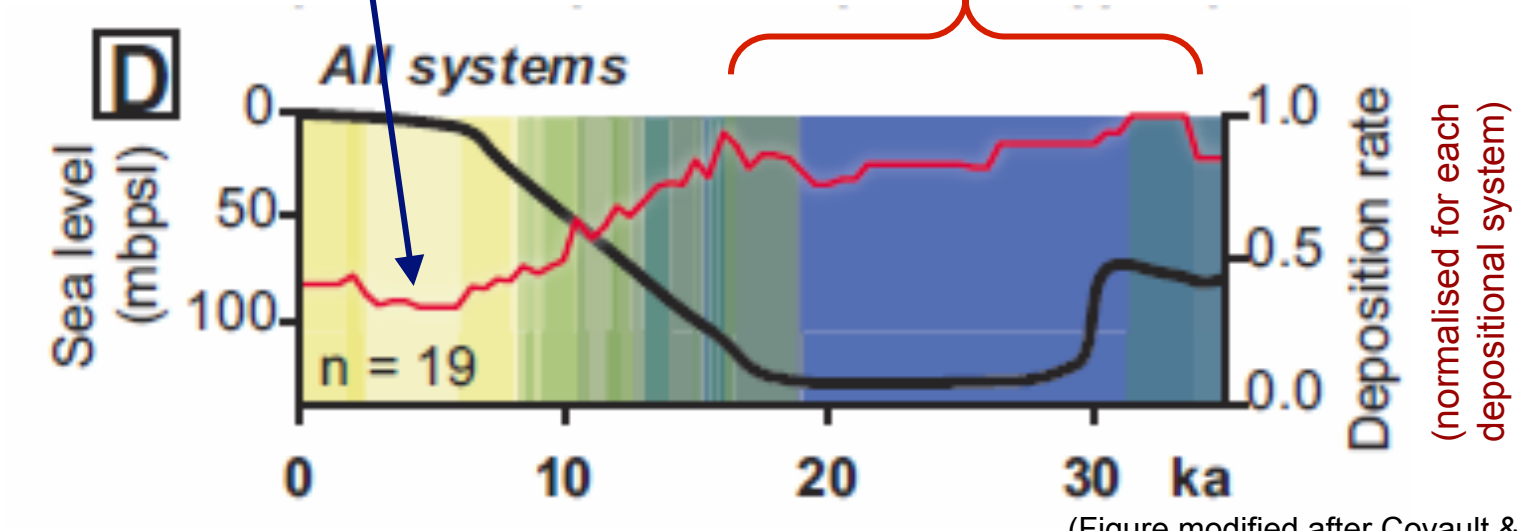
Deep-sea deposition and sea level: the global nuts and bolts



Consistent with classical stratigraphy, deep-sea deposition highest during lowstand and transgression

"Deep-sea deposition can occur at any state of sea level"

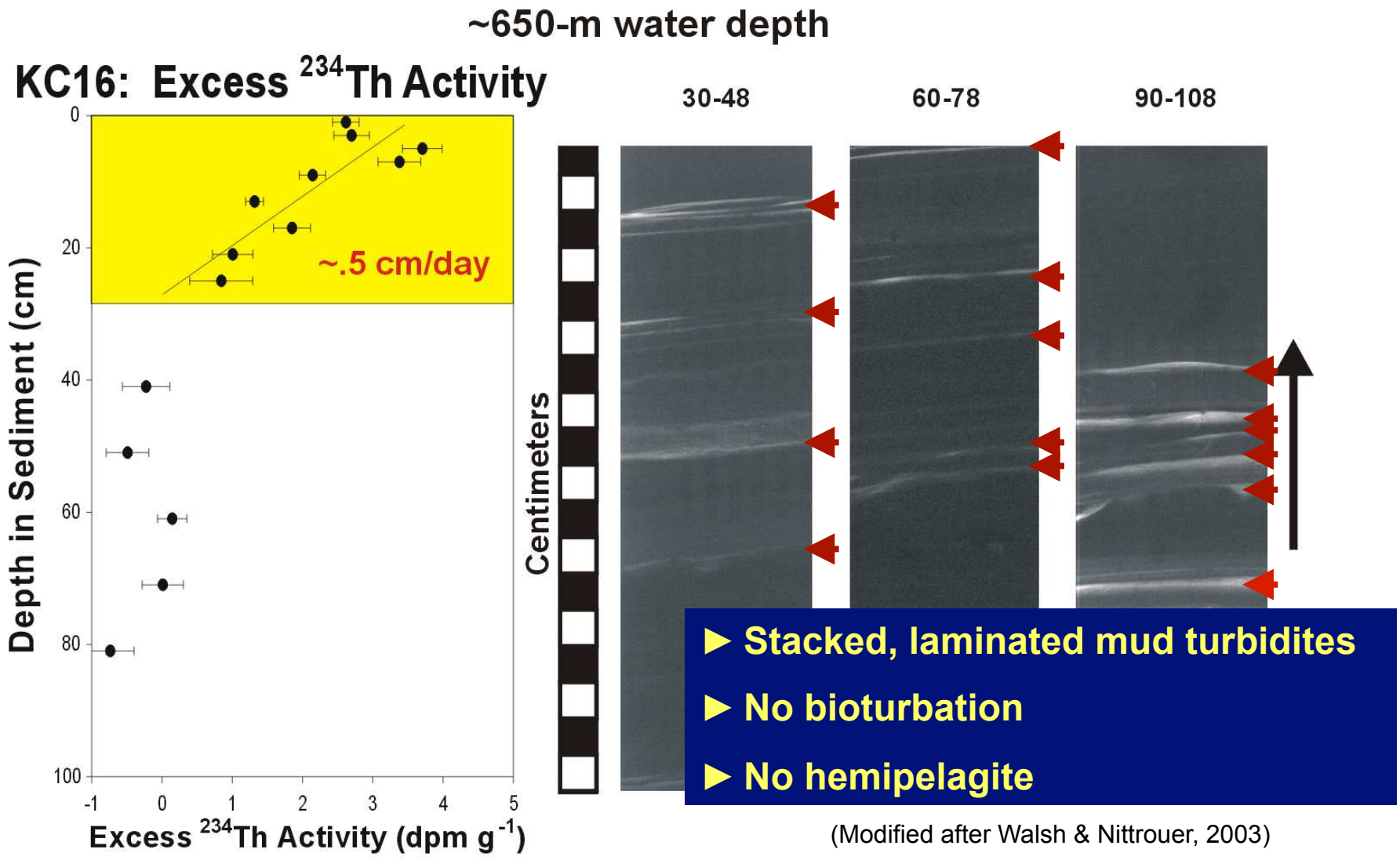
… but tectonics, climate, oceanography, shelf morphology and human impacts control timing of sediment transfer



(Figure modified after Covault & Graham, 2010)

1a: Timing of sediment transfer in closely-coupled catchment and deep-ocean systems

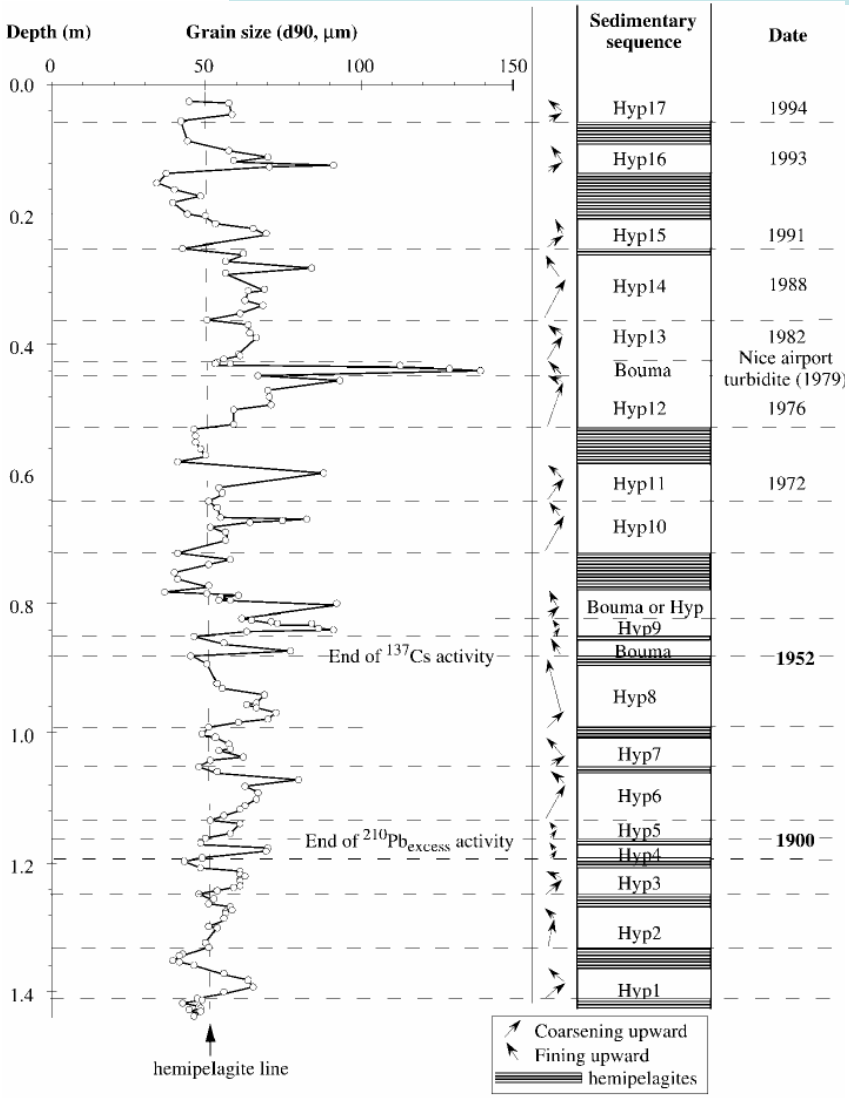
Rapid and frequent slope nourishment by gravity flows at Sepik mouth: an analogy for lowstand behaviour



(Modified after Walsh & Nittrouer, 2003)

Stratigraphic event chronology on slope directly linked to floods: a decadal view

(e.g. Var River Canyon)

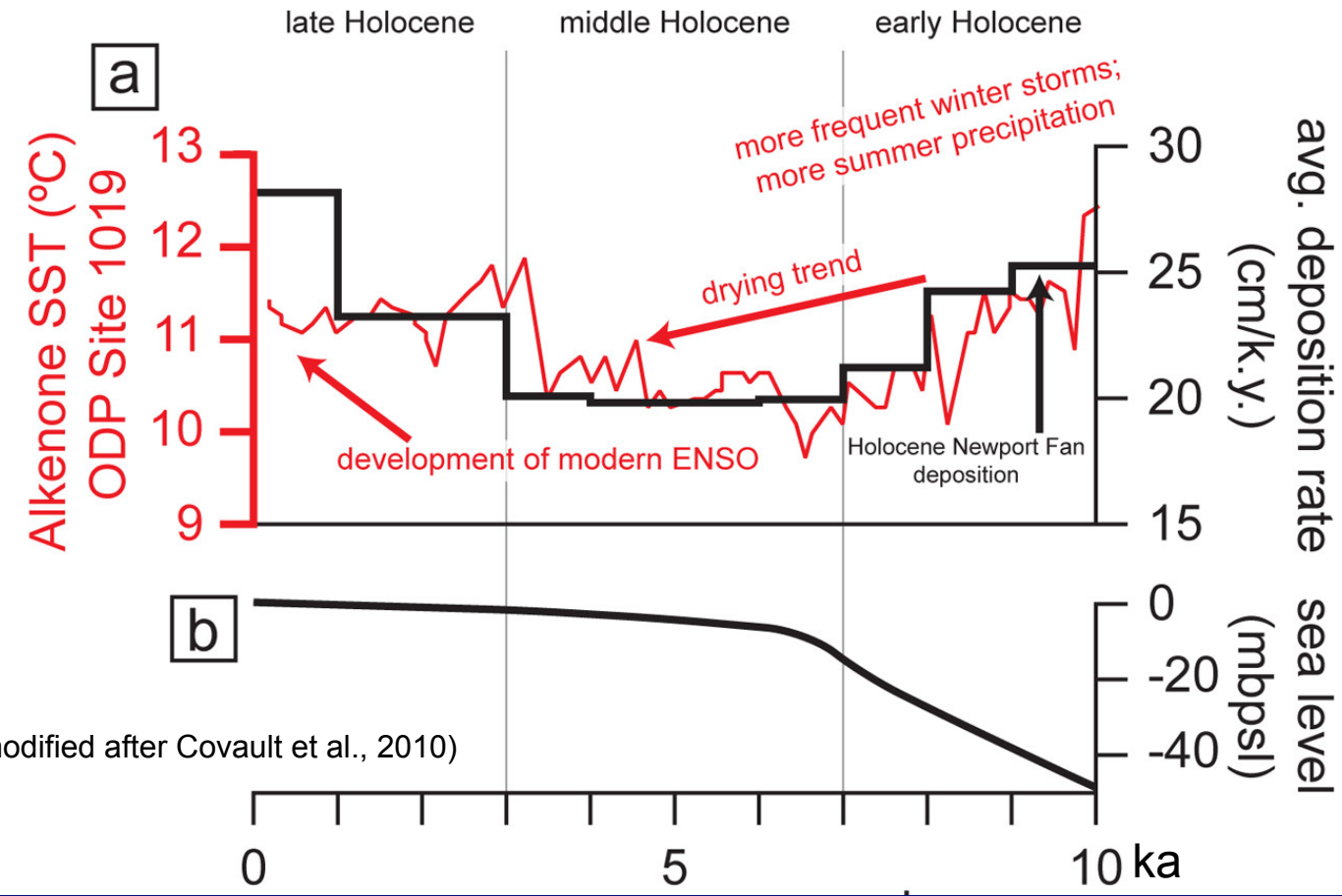


(Figure modified after Mulder et al., 2001)

- **Gravity flows interpreted as hyperpycnites**
- **Individual event chronology tagged to historical floods**
- **High fidelity to terrestrial rather than marine events**

Unravelling closely-coupled riverine and deep-sea fan systems: a millennial view

(e.g. Santa Ana River)



(Figure modified after Covault et al., 2010)

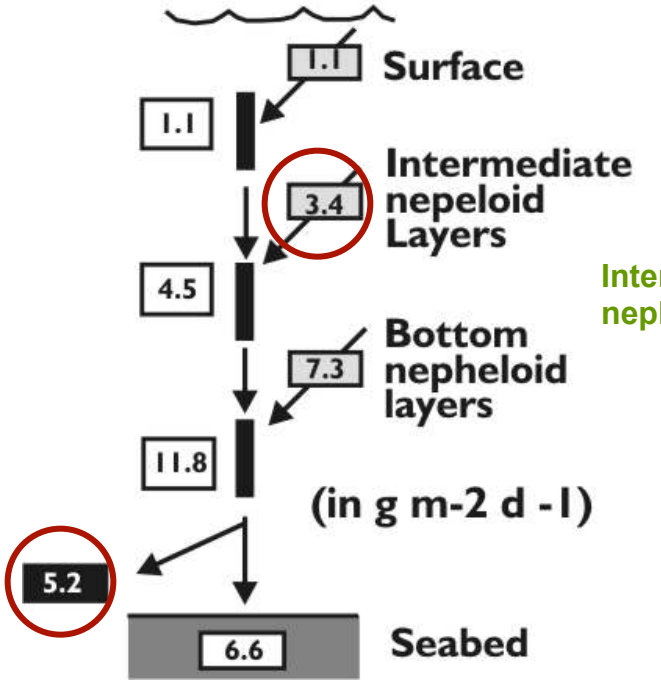
- **Efficient sediment routing via canyons**
- **Deep-sea fan deposition linked to rainfall and climate**
- **Sustained behavioural shifts from terrestrial fidelity**

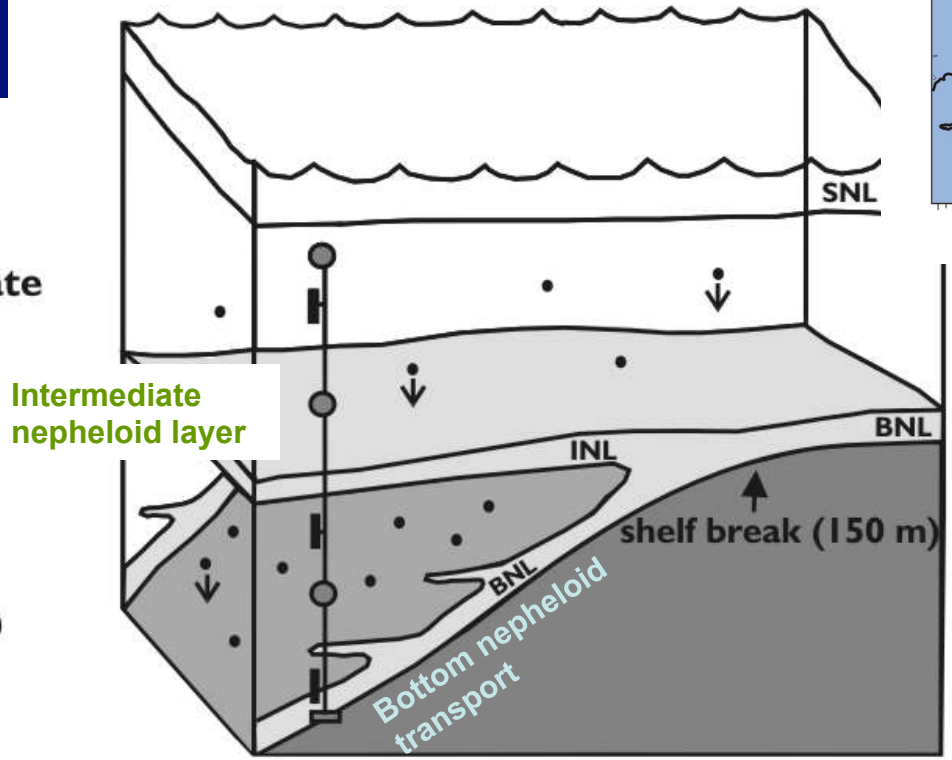
1b: Timing of sediment transfer in reactive catchments with strong oceanographic forcing

Timing of slope nourishment controlled by oceanographically enhanced dispersal

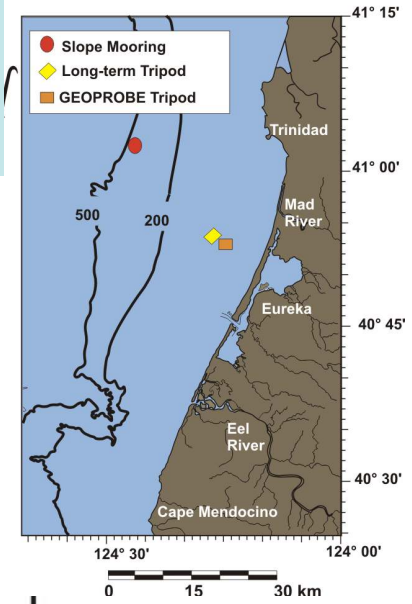
(e.g. Eel, Gulf of Lions, Waipaoa)

50% of slope sediment from intermediate nepheloid transport





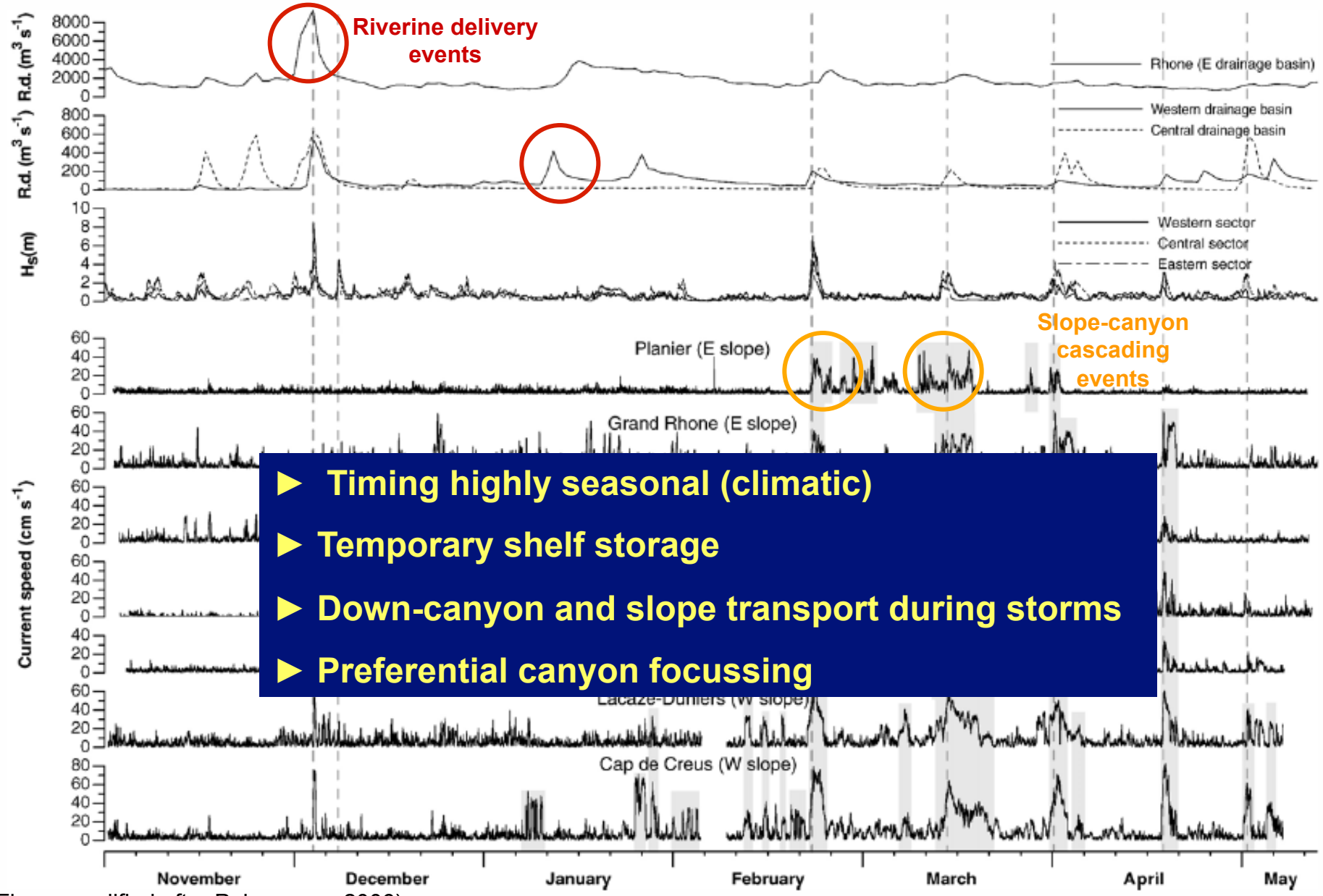
Intermediate nepheloid layer



(Figure modified after Walsh & Nittrouer., 1999)

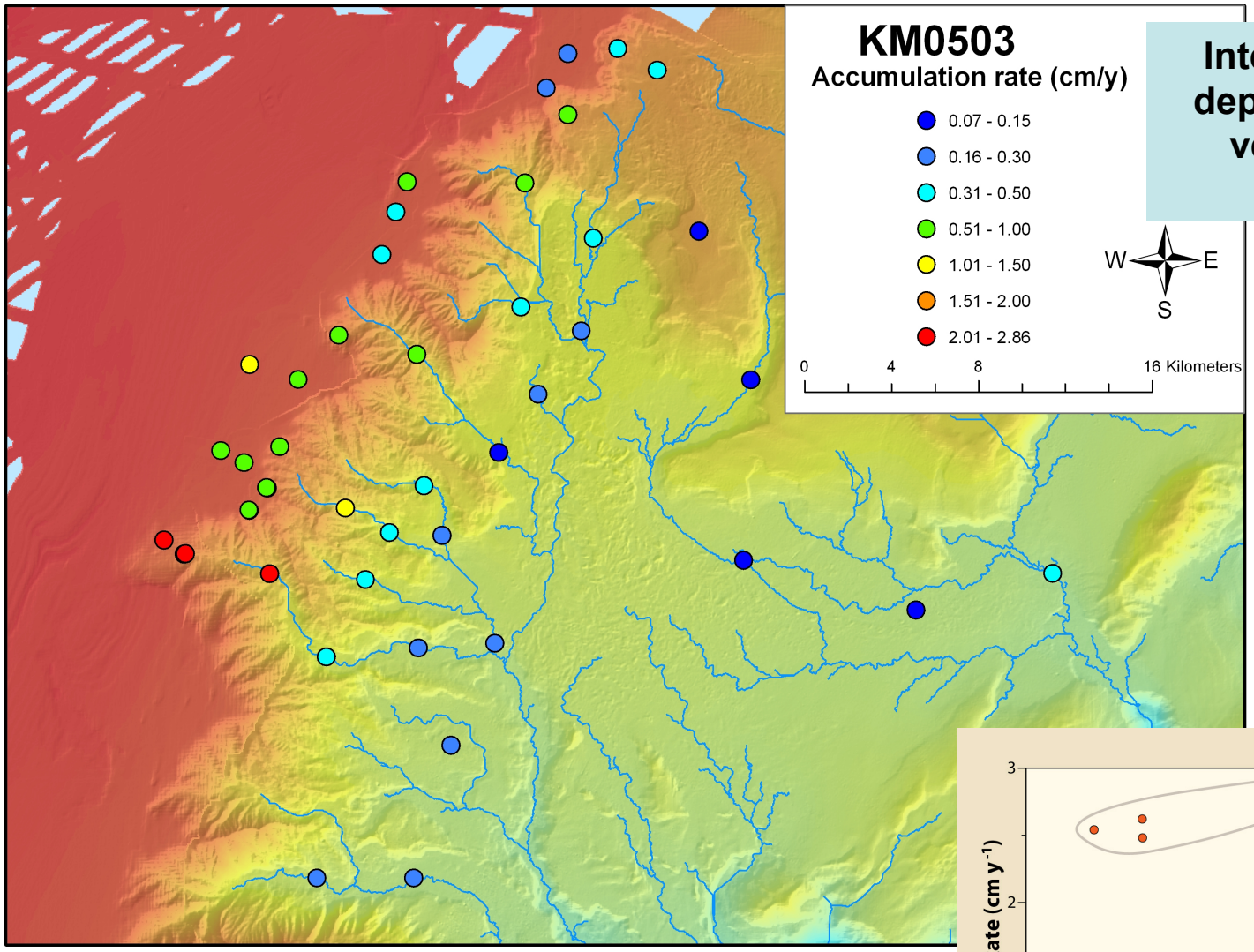
Moderate-weak fidelity to terrestrial events

Timing of slope nourishment controlled by climatically and oceanographically enhanced dispersal (e.g. Gulf of Lions, Eel)

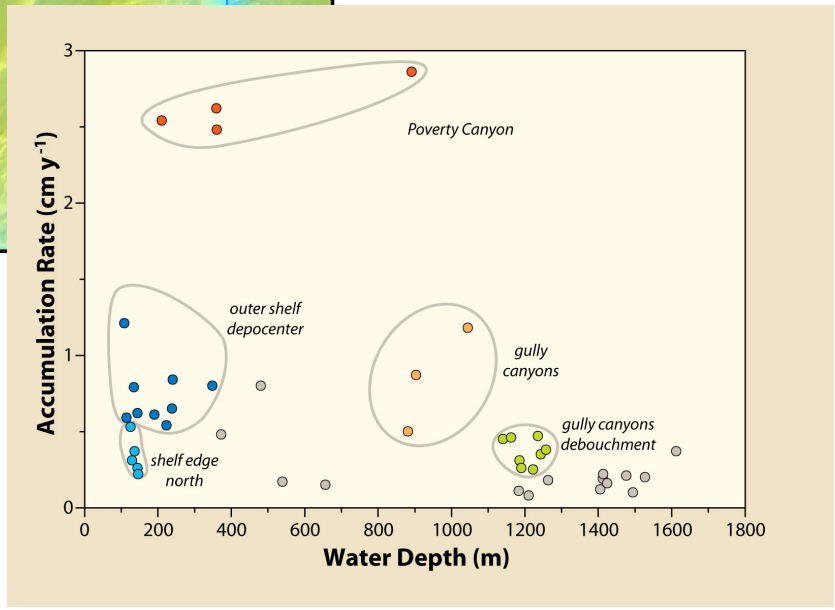


- Timing highly seasonal (climatic)
- Temporary shelf storage
- Down-canyon and slope transport during storms
- Preferential canyon focussing

(Figure modified after Palanques., 2006)



Inter- and intra-canyon deposition: background versus event-driven sedimentation

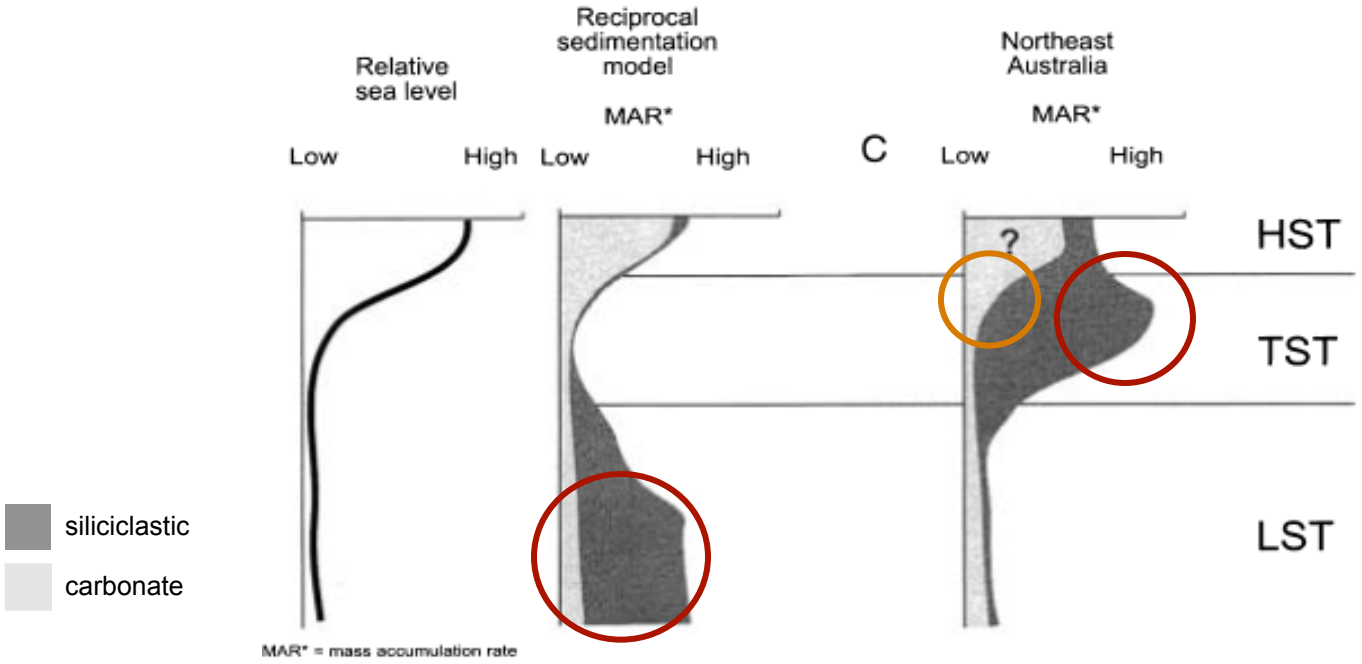


- ► Timing potentially seasonal (climatic)
- ► Temporary storage within canyon heads
- ► Likely climatic and tectonic triggers

(modified after Alexander et al.,2010)

2: Mixed carbonate-siliciclastic systems and glacio-eustatic timing

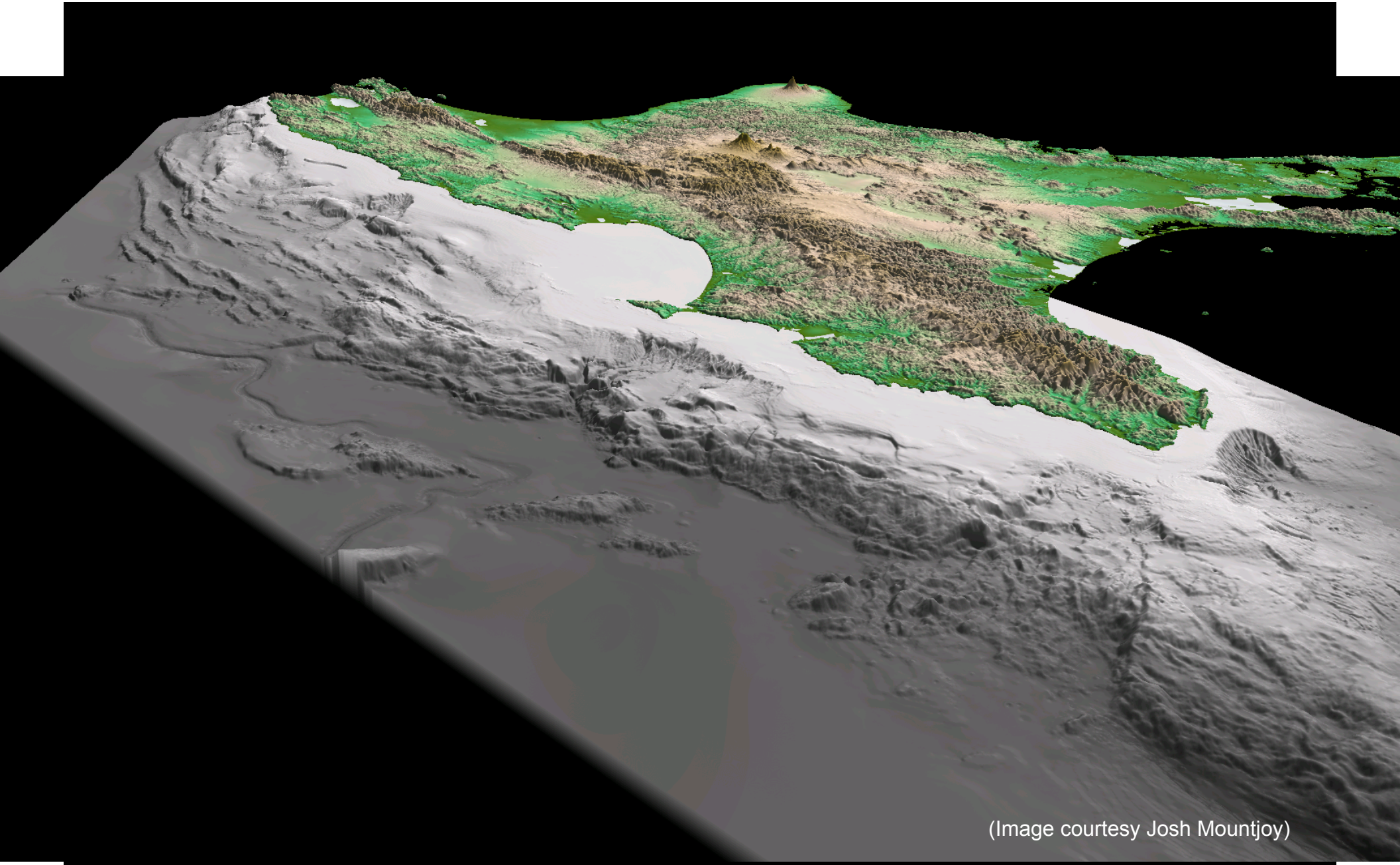
Glacio-eustatic control on carbonate production and terrestrial supply



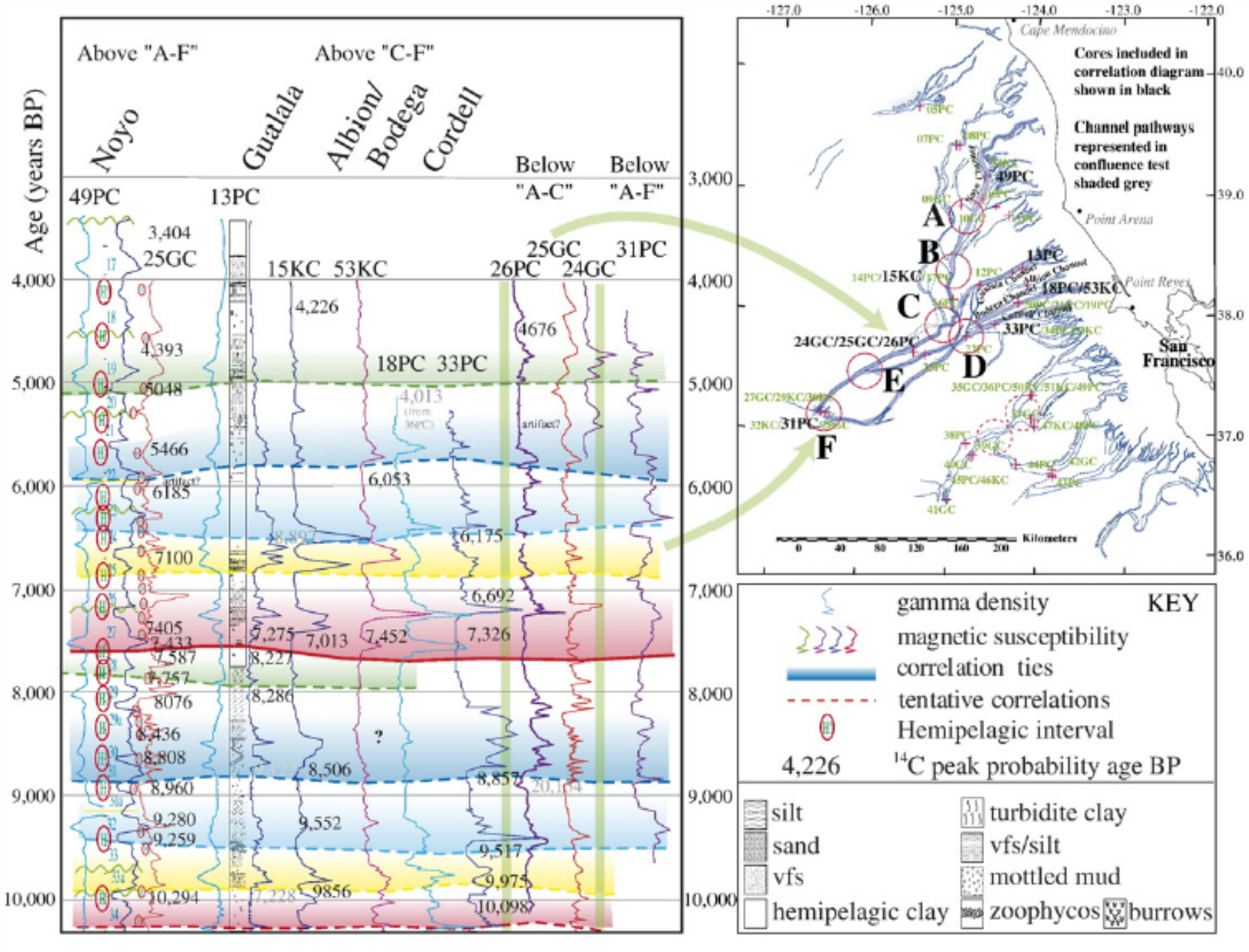
(Figure modified after Dunbar & Dickens, 2003)

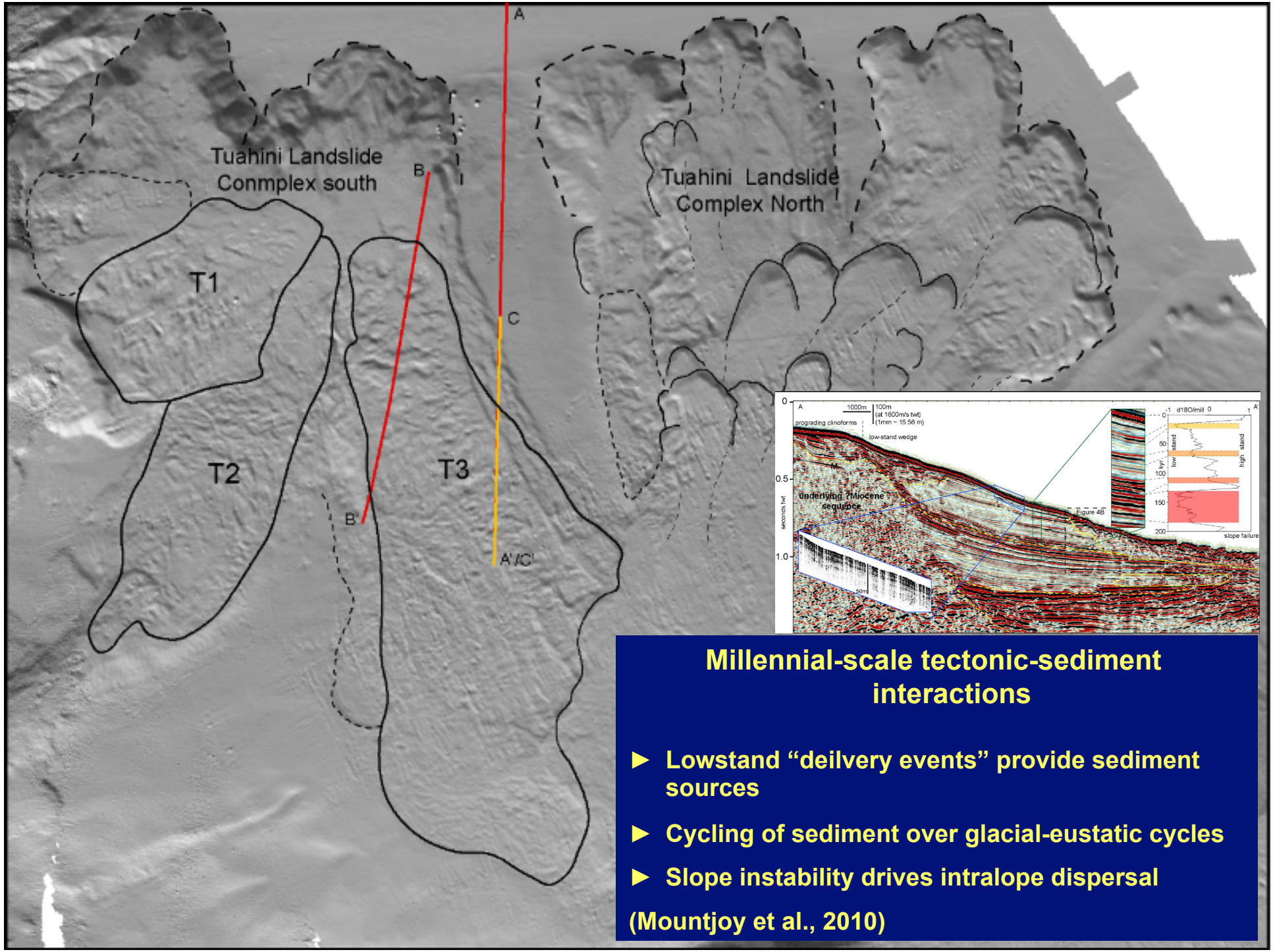
- **Timing of peak terrigenous flux to slope during lowstand <u>OR</u> transgression**
- **Transgressive shedding applicable to siliciclastic margins also (Santa Monica Bay, Sommerfield & Lee 2004)**
- **Coincident reef initiation in turbid coastal water**

3. Intra-slope sources and tectonically-forced timing



NIWA
Taihoro Nukurangi

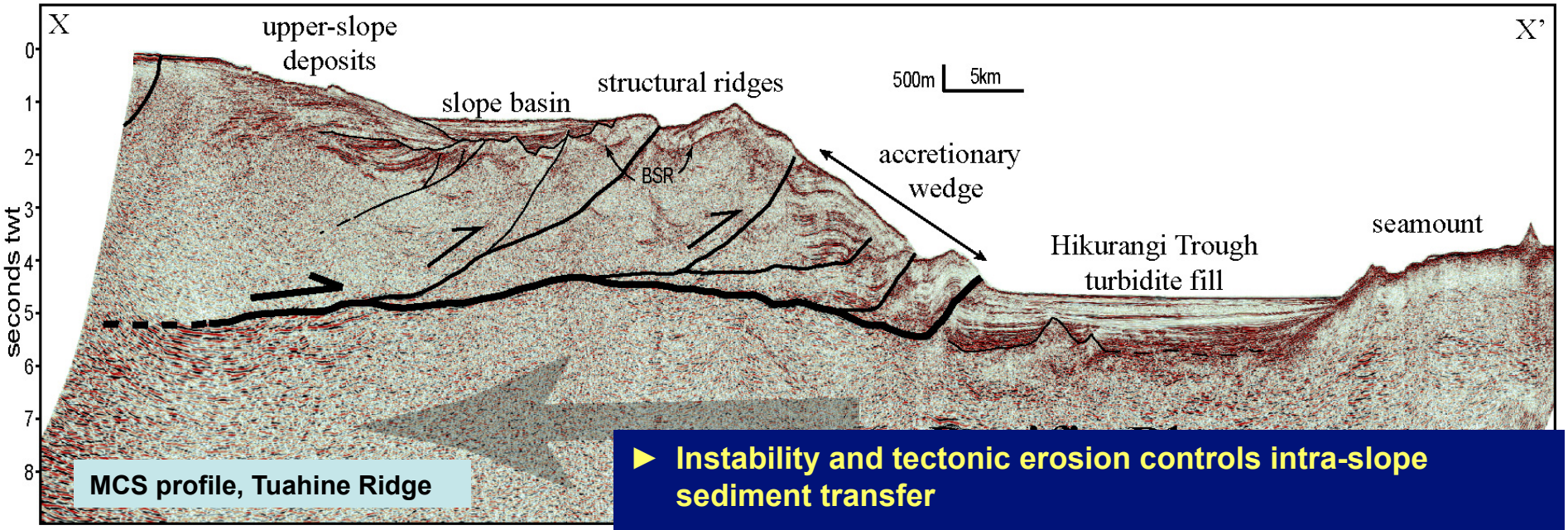

Above "A-F"
Above "C-F"
Noyo
Gualala
Albion/
Bodega
Cordell
Below "A-C"
Below "A-F"
49PC
13PC
25GC
15KC 53KC
26PC 24GC
31PC
18PC 33PC
Age (years BP)
4,000
5,000
6,000
7,000
8,000
9,000
10,000
3,404
4,393
5048
5466
6185
7100
7405
7,433
7,587
7,757
8076
8,436
8,808
8,960
9,280
9,259
10,294
4,226
4676
4,013
artifact?
6,053
6,175
6,692
7,275
7,013
7,452
7,326
8,227
8,286
8,506
8,857
9,552
9,517
9,975
10,098
7,228
9856
Cape Mendocino
Cores included in correlation diagram shown in black
Channel pathways represented in confluence test shaded grey
Point Arena
Point Reyes
San Francisco
24GC/25GC/26PC
27GC/29KC/30PC
31PC
Kilometers
KEY
gamma density
magnetic susceptibility
correlation ties
tentative correlations
Hemipelagic interval
4,226 14C peak probability age BP
silt
sand
vfs
hemipelagic clay
turbidite clay
vfs/silt
mottled mud
zoophycos
burrows



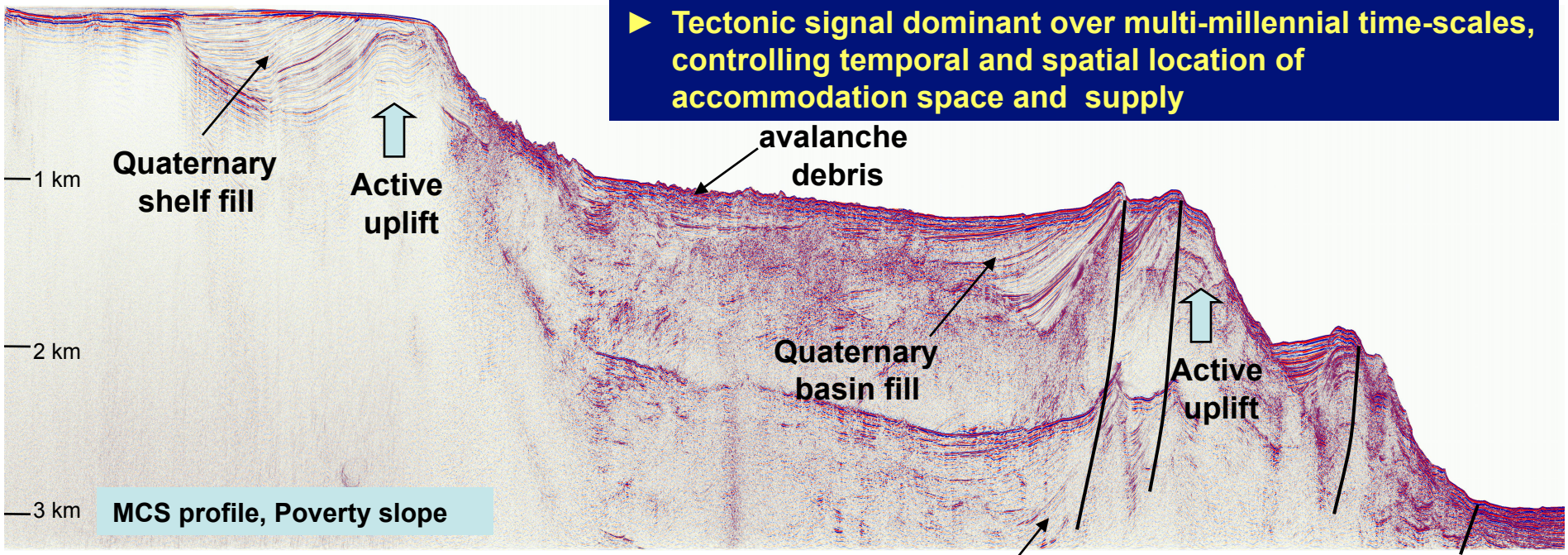
Millennial-scale tectonic-sediment interactions

- Lowstand "deilvery events" provide sediment sources
- Cycling of sediment over glacial-eustatic cycles
- Slope instability drives intralope dispersal

(Mountjoy et al., 2010)

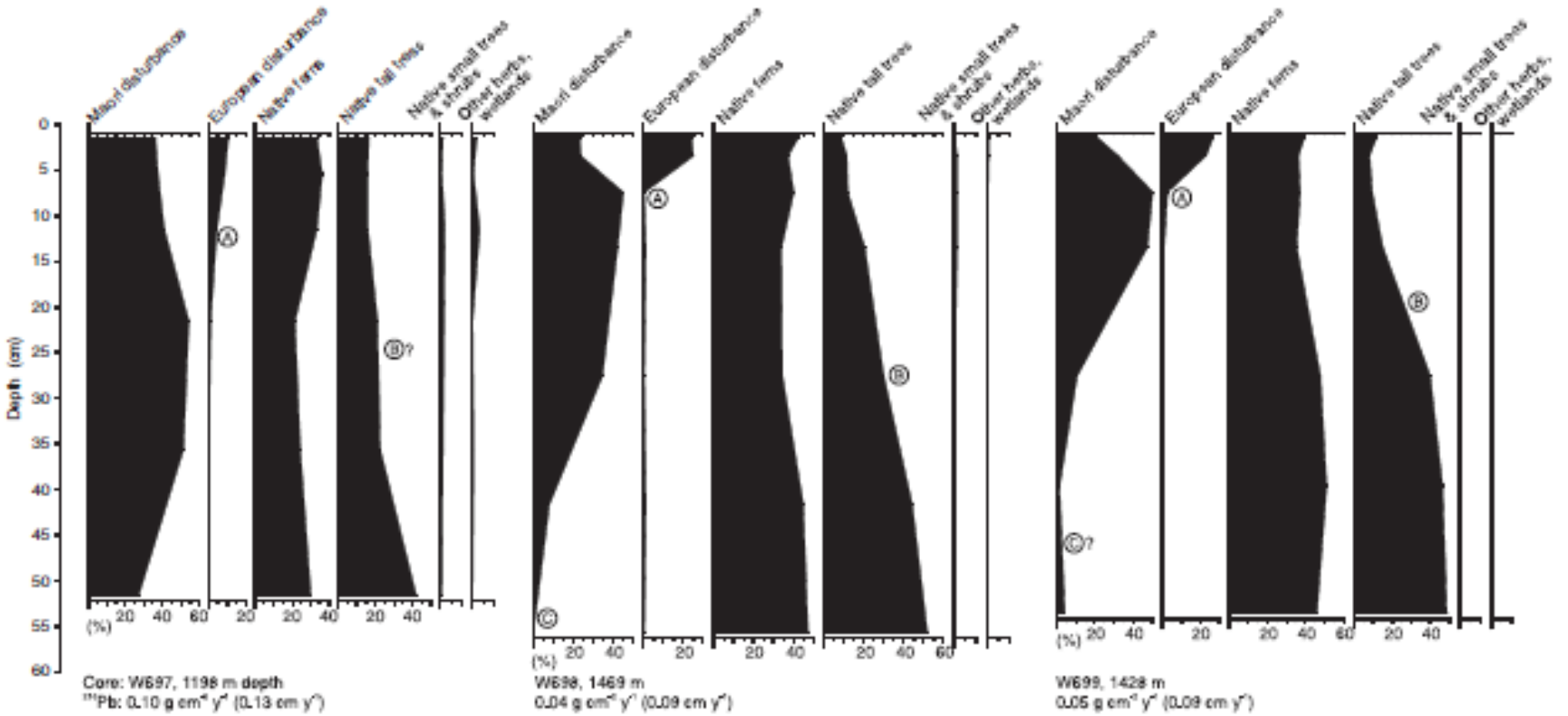


- **Instability and tectonic erosion controls intra-slope sediment transfer**
- **Tectonic signal dominant over multi-millennial time-scales, controlling temporal and spatial location of accommodation space and supply**



(Figures modified after Mountjoy in press, Lewis & Orpin, 2003)

4. The (human)fly in the ointment: the anthropogenic signal as an event and driver

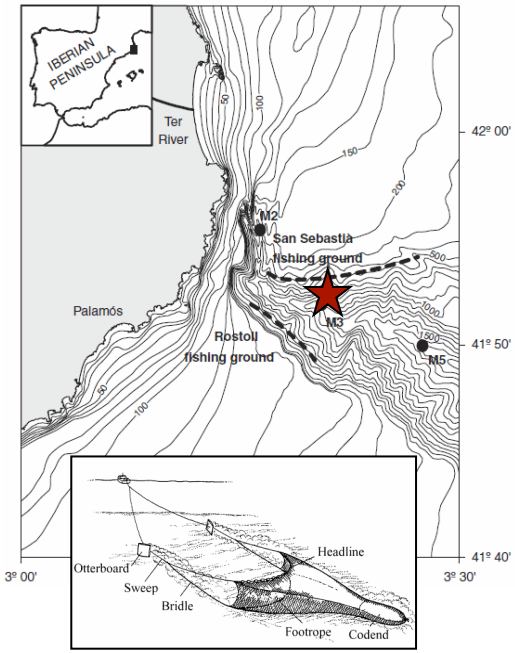


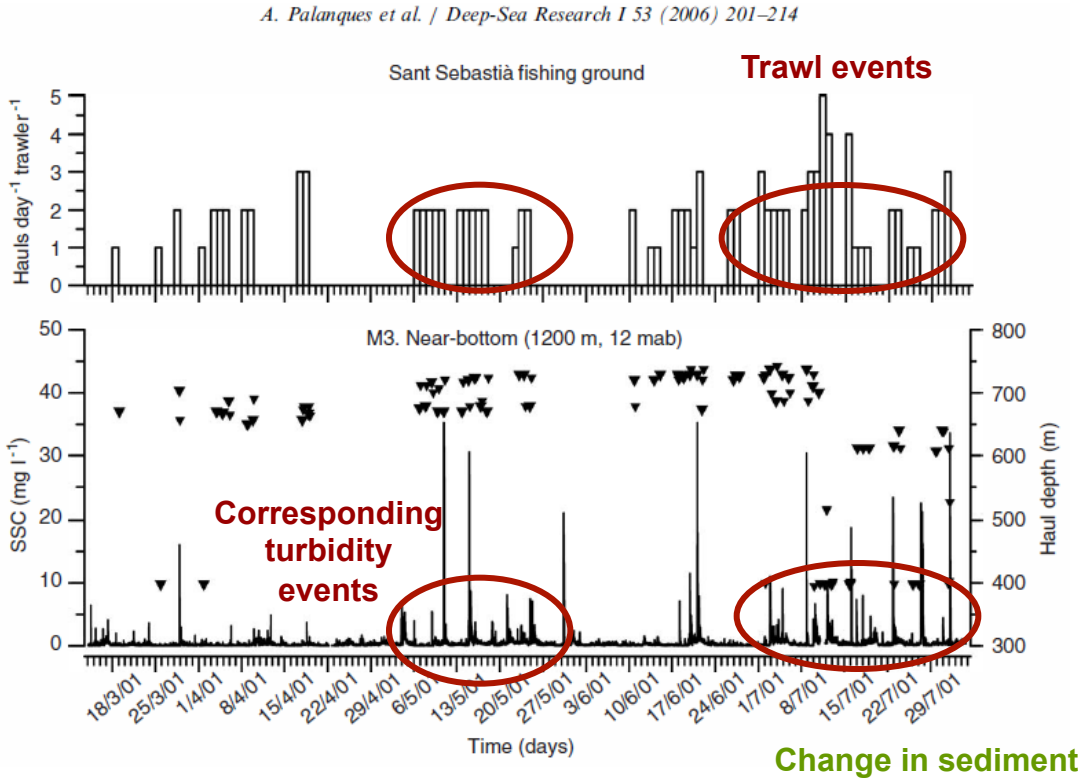
Ⓐ Establishment of open pastures ~ 1900 AD
Ⓑ Estimated European arrival ~1850 AD
Ⓒ Progressive decline in native forests upon Maori occupation from ~700 y BP

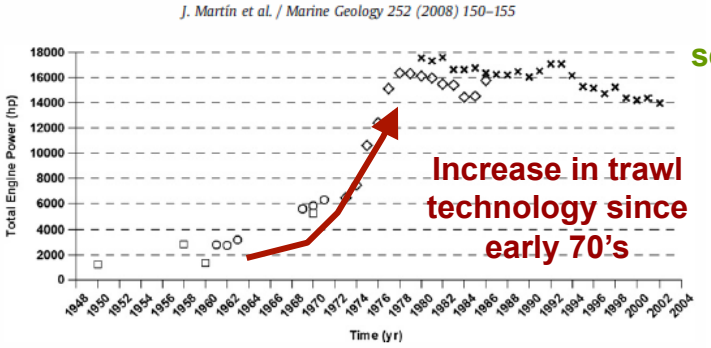
Maori Disturbance	European Disturbance	Native Ferns	Native Tall Trees	Native Small Trees and Shrubs	Other Herbs, Wetlands
Pteridium esculentum	*Pinus spp.*	*Cyathea spp.*	*Dacrydium cupressinum*	*Halocarpus*	*Poaceae*
Lycopodium spp.	*Taraxacum*	Smooth monolete spores	*Podocarpus/Prumnopitys*	*Coprosma*	*Restionaceae*
Anthocerotales	*Cupressaceae*	Other spores	*Phyllocladus*	*Asteraceae*	*Cyperaceae*
Corlaria	*Salix*		*Nothofagus spp.*	*Dracophyllum*	*Typha*
			Agathis australis/Araucariaceae	*Ascarina lucida*	*Haloragis*
			Dacrycarpus dacrydioides	*Weinmannia*	*Sarocornia*
			Libocedrus	*Metrosideros*	
				Hedycarya arborea	
				Alectryon	
				Tupeia antarctica	
				Pseudopanax	
				Laurelia novae-zelandiae	
				Myrsine	
				Plagianthus	
				Araliaceae	
				Pseudowintera	

- **Evidence of Polynesian and European settlement captured on slope record**
- **Efficiency of signal transfer by diffusive processes on slope stratigraphy**

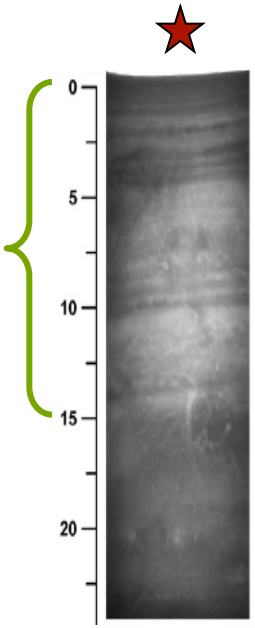
Localised effects: timing of slope dispersal enhanced by trawling activity





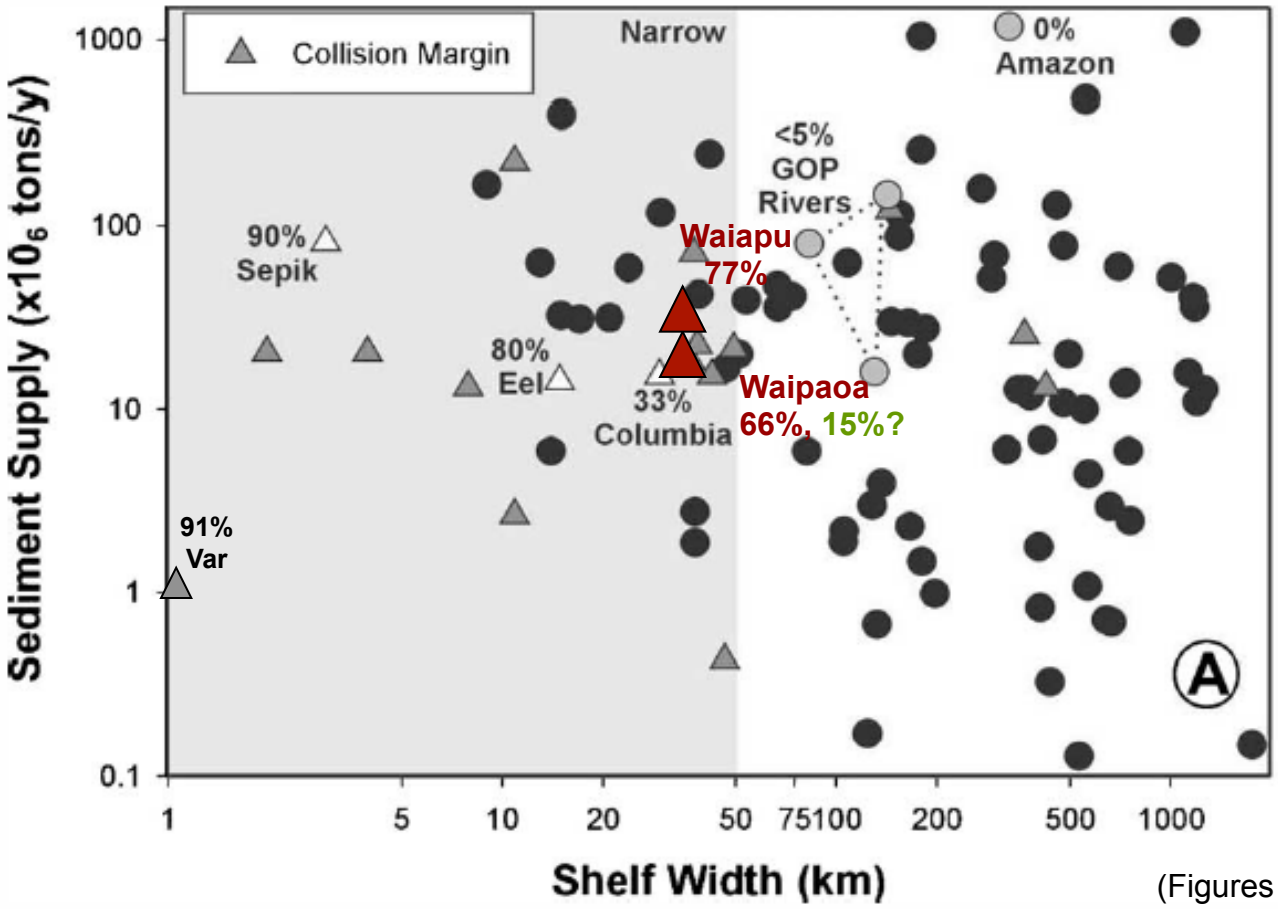


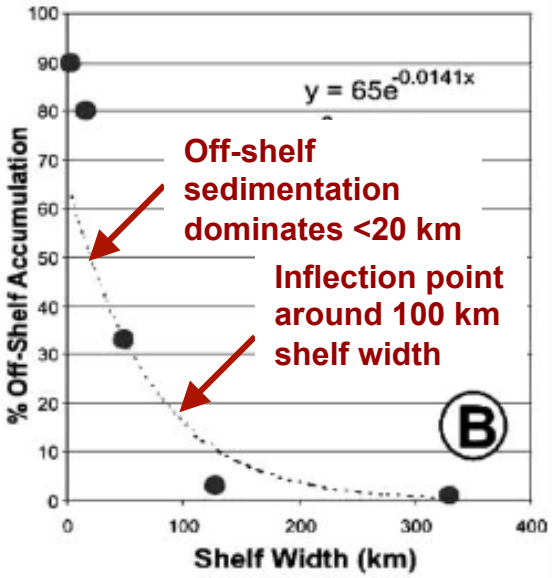
Change in sediment structure from increase in sedimentation



Likelihood of anthropogenic signature preserved in slope record

Margin scale: influence of shelf width and supply on off-shelf dispersal - have we tipped the scales?

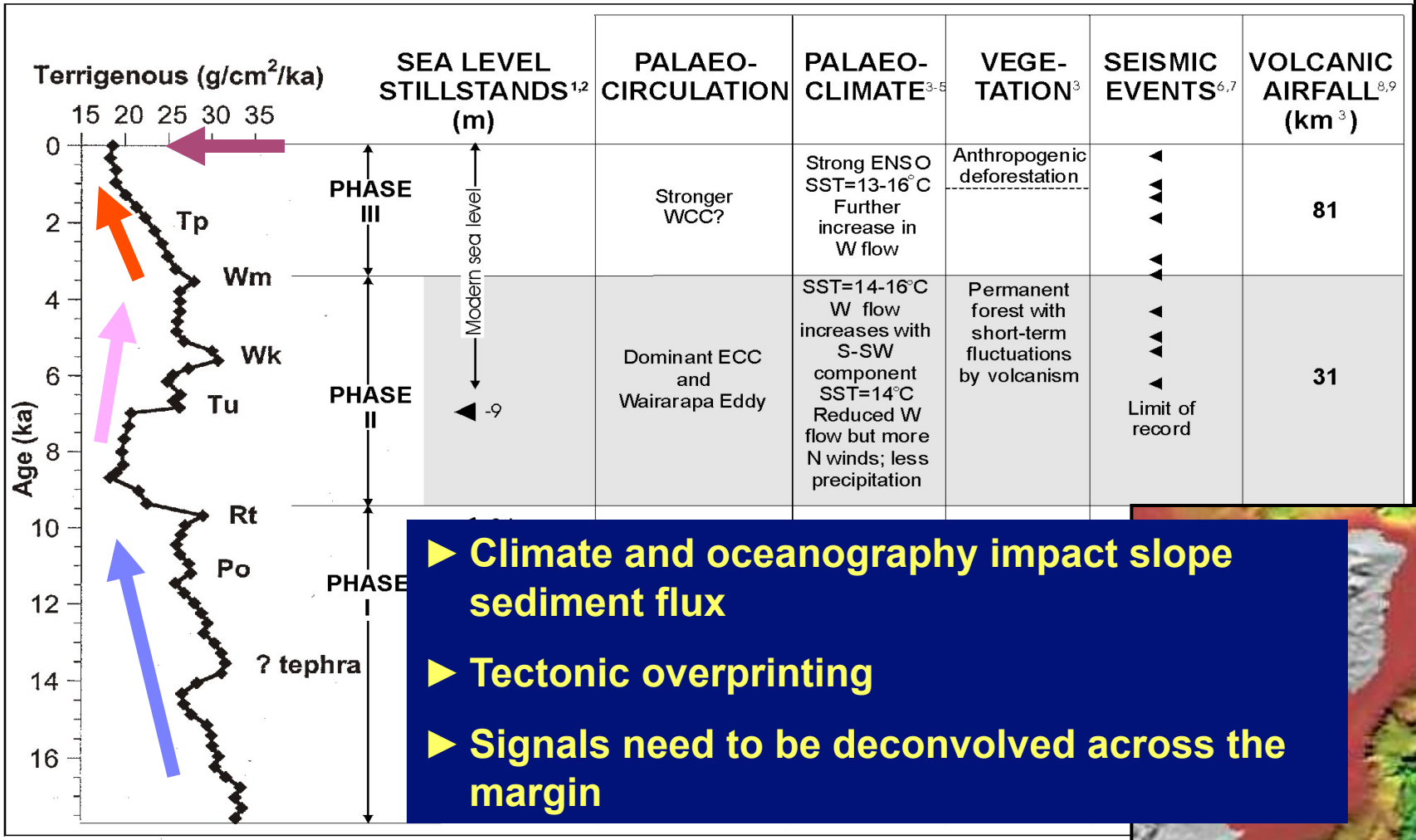




(Figures modified after Walsh & Nittrouer, 2003)

- Have anthropogenic impacts in the Waipaoa catchment overwhelmed margin morphology as the dominant control on off-shelf sediment transfer?
- Is there a natural analogue in the rock record?

Post-glacial climate and erosion record through the eye of the tectonic needle



- Climate and oceanography impact slope sediment flux
- Tectonic overprinting
- Signals need to be deconvolved across the margin

(Figure modified after Carter et al., 2002)

In a noisy system, the construct of the question may constrain the scope of the answer