

Stratigraphic Signals of Shelf-Edge Delta Progradation with Special Reference to Delta-Front Turbidites: Upper Cretaceous Tres Pasos and Dorotea Formations, Magallanes Basin, Chile*

By

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Abstract

This study utilizes superbly-exposed outcrops of the Upper Cretaceous Tres Pasos (delta-fed deep-marine slope) and Dorotea (shallow-marine and deltaic) formations of southern Chile to analyze shelf-edge delta progradation at the resolution of individual beds and packages of beds. Coarse-grained shelf-edge strata at the informally-named Cerro Escondido outcrop are >300 m thick and include two upward-coarsening successions of turbidites overlain by hummocky cross-stratified beds. The uppermost turbidite-hummocky bed succession is overlain by trough cross-stratified sandstone encased in carbonaceous mudstone interpreted to have been deposited in distributary and interdistributary deltaic environments. The thick section (>50 m) of turbidites between hummocky beds exhibits progressively thinner turbidites and an overall increase in sand richness upwards. Preservation of this section implies relatively abrupt and large-magnitude relative sea-level fluctuations, which prevented extensive reworking of turbidites by the combined storm-wave and unidirectional currents that create hummocky cross stratification. The observed turbidite stacking pattern reflects the increased occurrence of relatively frequent and dilute sediment gravity flows, such as might be initiated by decadal or centennial hyperpycnal fluvial discharge from a delta-channel mouth, and is thus a signal of progradation. This study shows that delta-front turbidite sections are significant components of continental margin-scale prograding shelf-slope systems.

Stratigraphic signals of shelf-edge delta progradation with special reference to delta-front turbidities: Upper Cretaceous Tres Pasos and Dorotea formations, Magallanes Basin, Chile



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Results and outline

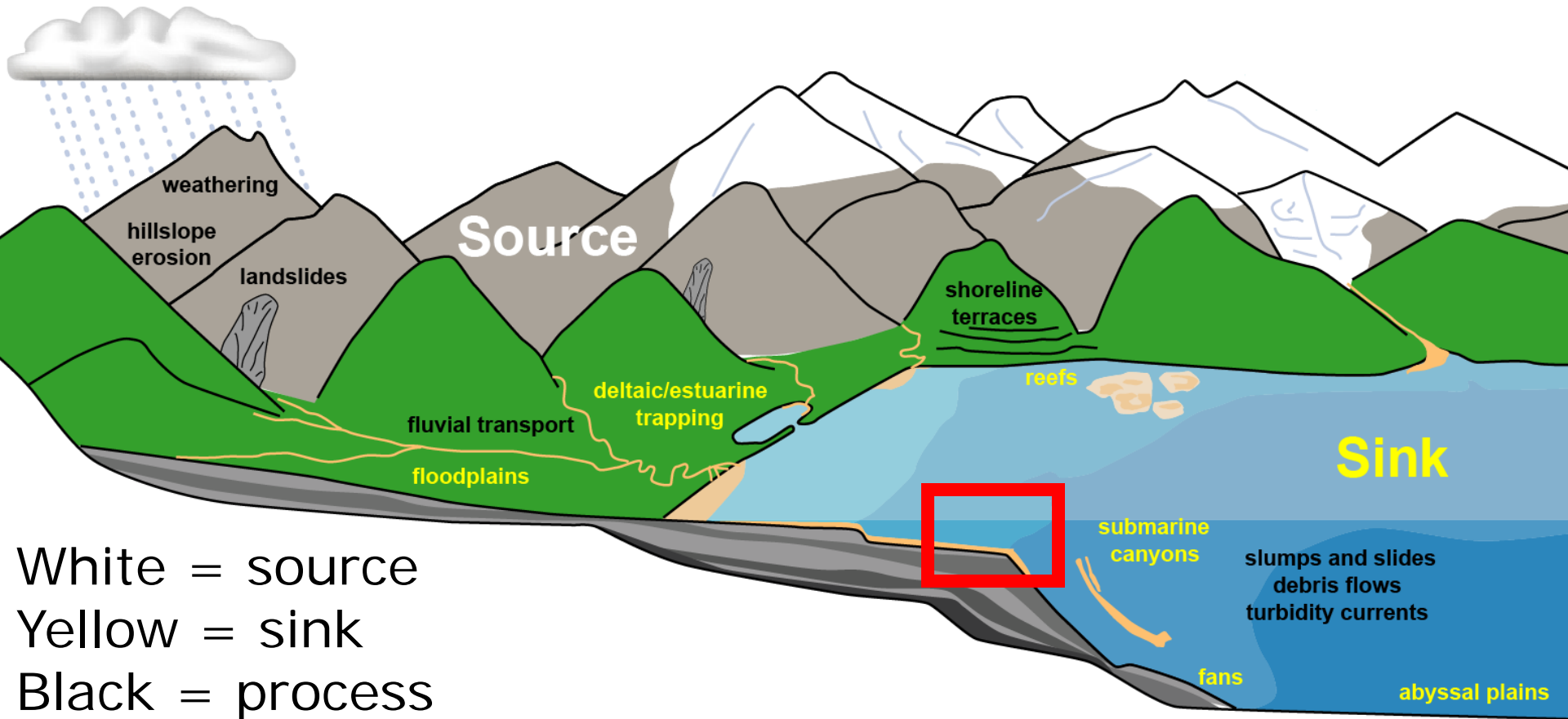
- Three lithofacies associations
 - Turbidite lithofacies
 - HCS and SCS lithofacies
 - TCS and mudstone lithofacies
 - **Turbidites in HCS/SCS “sandwich”**
- Turbidites progressively thinner, with overall increase in sand richness, upward
 - Reflects increased occurrence of relatively frequent and dilute flows
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Critical transition zone linking source to sink

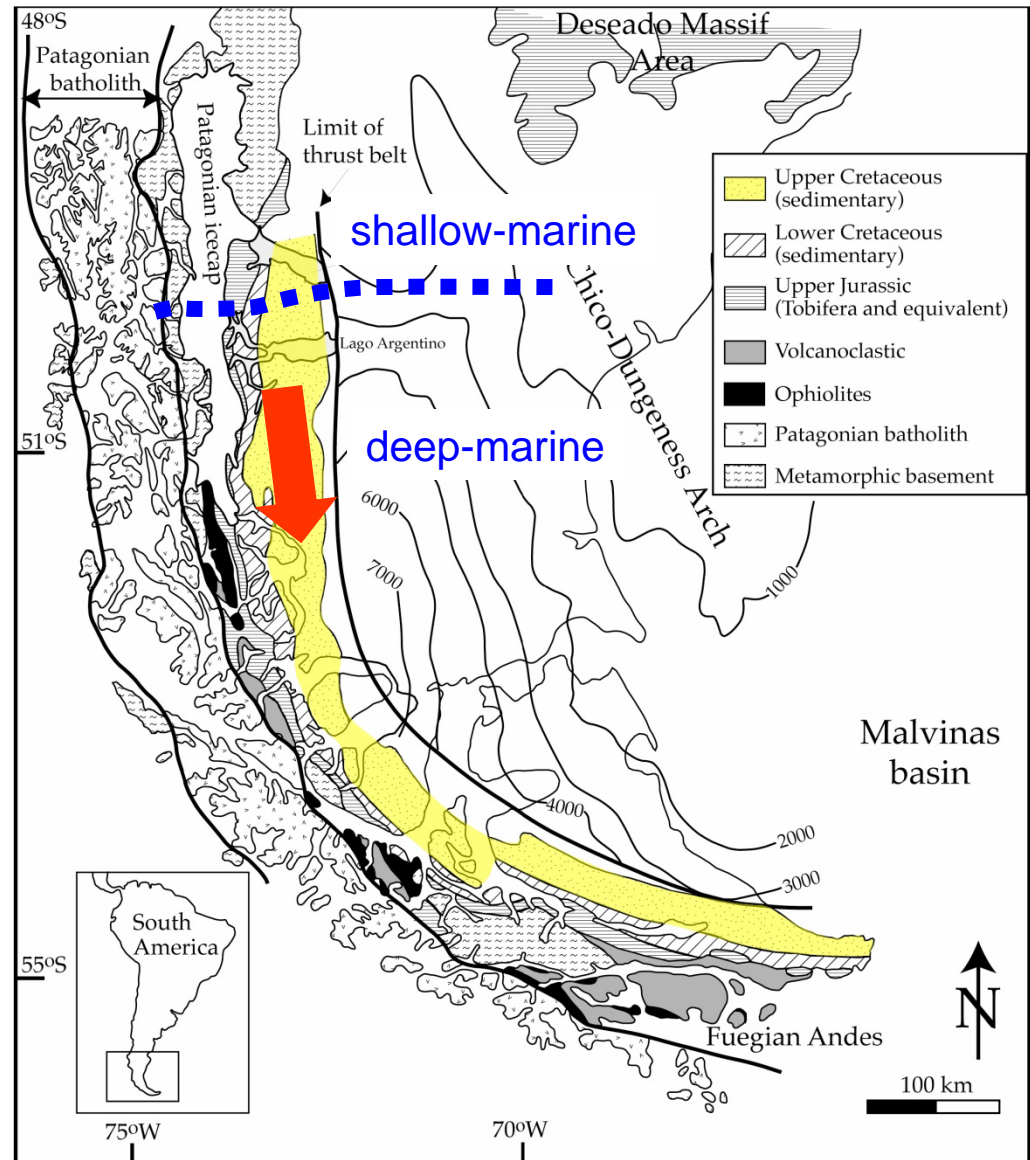
- Recent work
 - Quaternary shelf-edge deltas in Gulf of Mexico (seismic)
 - Eocene Central Basin, Spitsbergen (outcrop)



(<http://www.nsf-margins.org>)

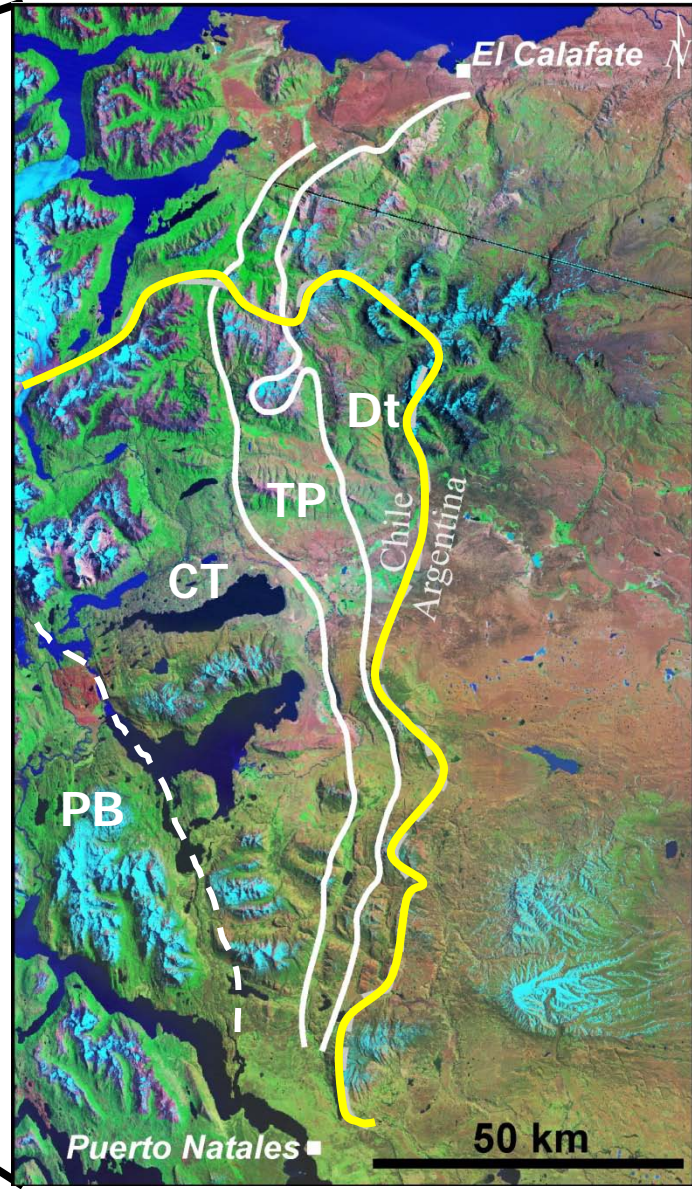
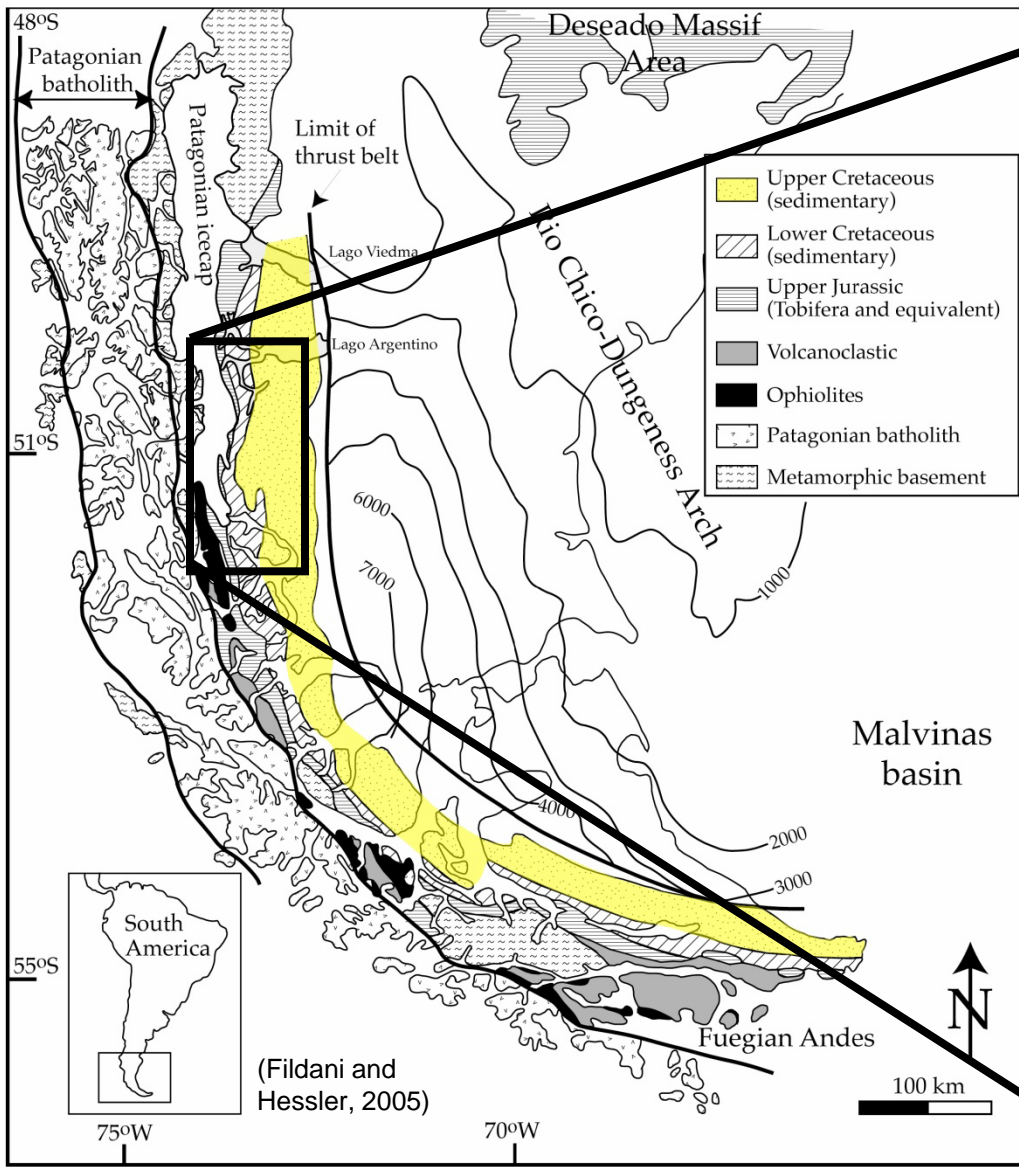
Magallanes foreland basin of southern Chile

- Retroarc foreland basin adjacent to Andean arc
- Bounded on the north and east by Paleozoic metasedimentary highs
- Upper Cretaceous foredeep sediments exposed in present-day fold-thrust belt



(Fildani and Hessler, 2005)

Ultima Esperanza region of Patagonia

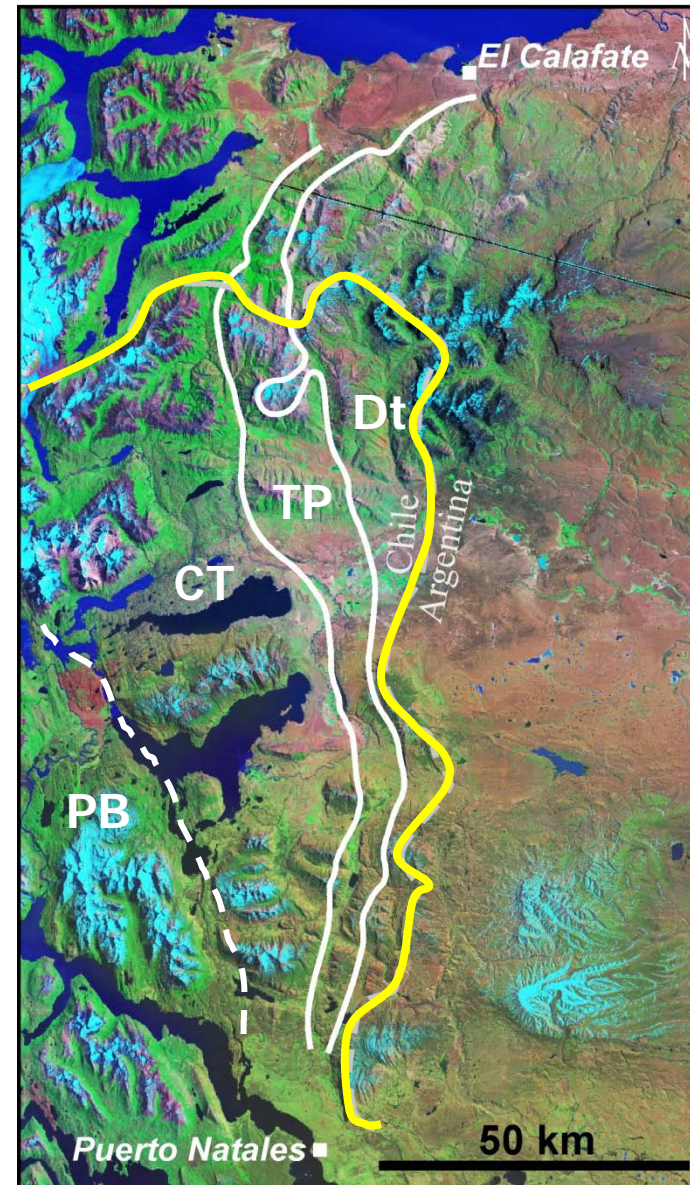


Upper Cretaceous Magallanes Basin fill

- Strata exhibit strong south-directed paleocurrent

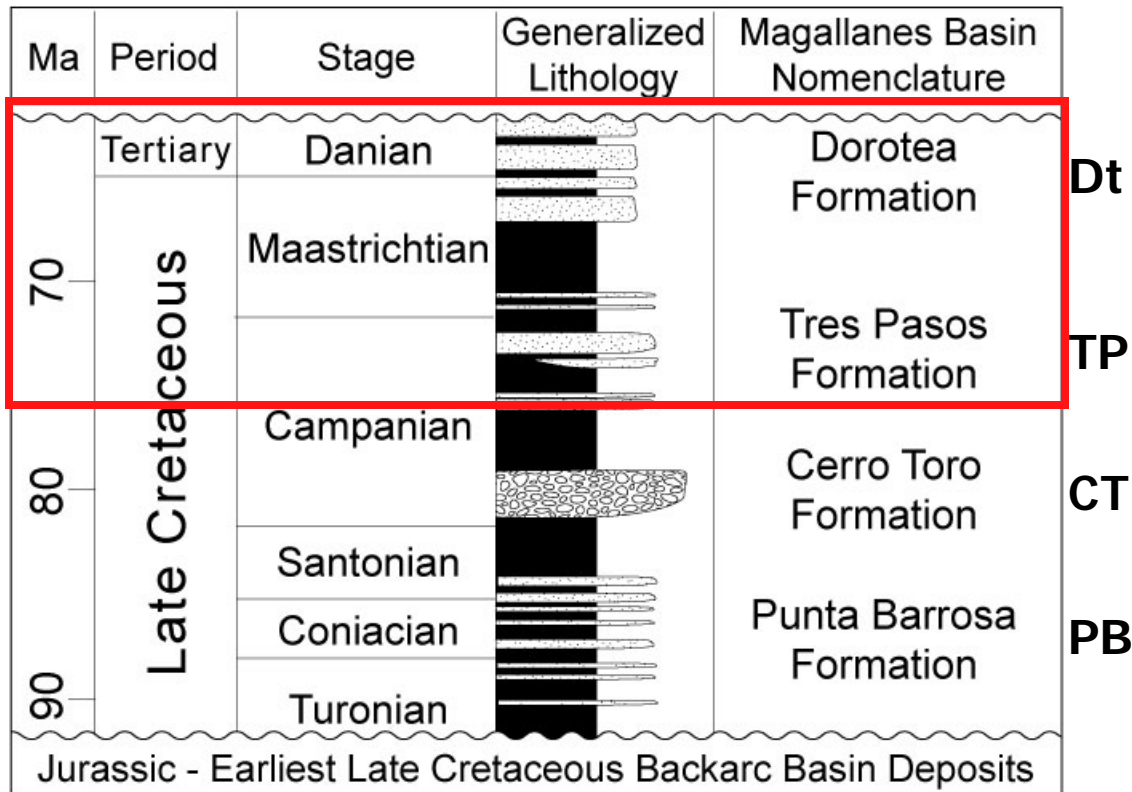
Ma	Period	Stage	Generalized Lithology	Magallanes Basin Nomenclature
70	Tertiary	Danian		Dorotea Formation
		Maastrichtian		Tres Pasos Formation
80	Late Cretaceous	Campanian		Cerro Toro Formation
		Santonian		Punta Barrosa Formation
		Coniacian		
90		Turonian		
Jurassic - Earliest Late Cretaceous Backarc Basin Deposits				

(Stratigraphic column from Hubbard, 2006; satellite image from NASA World Wind and modified by Brian Romans)

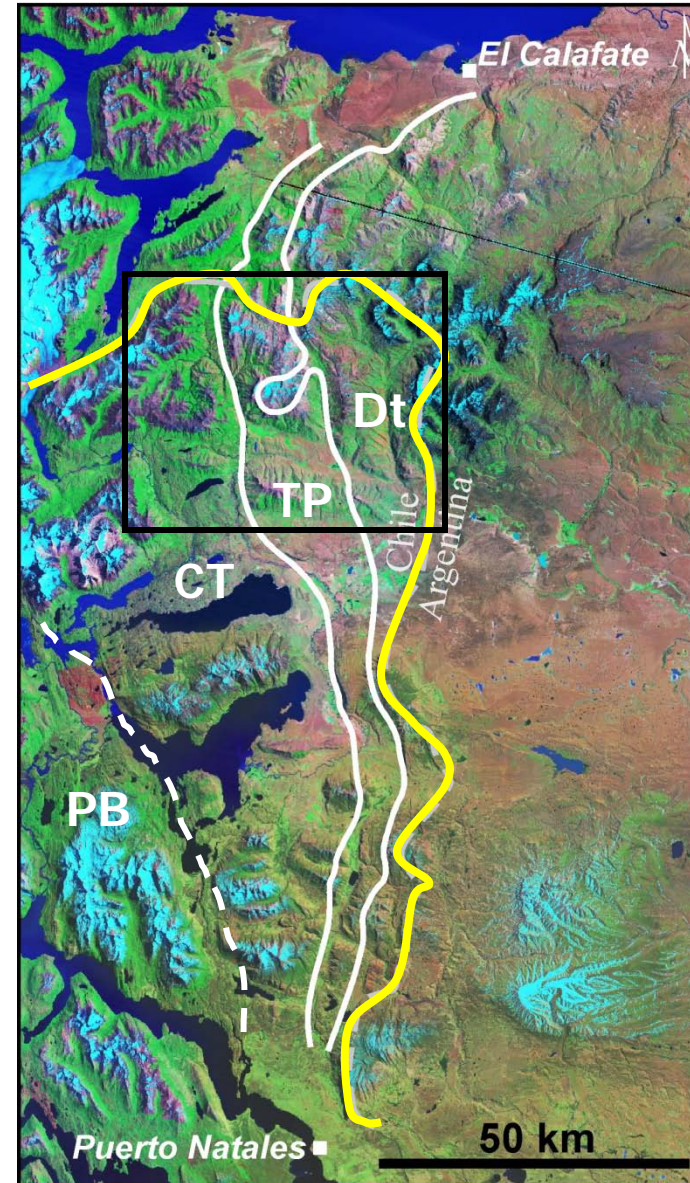


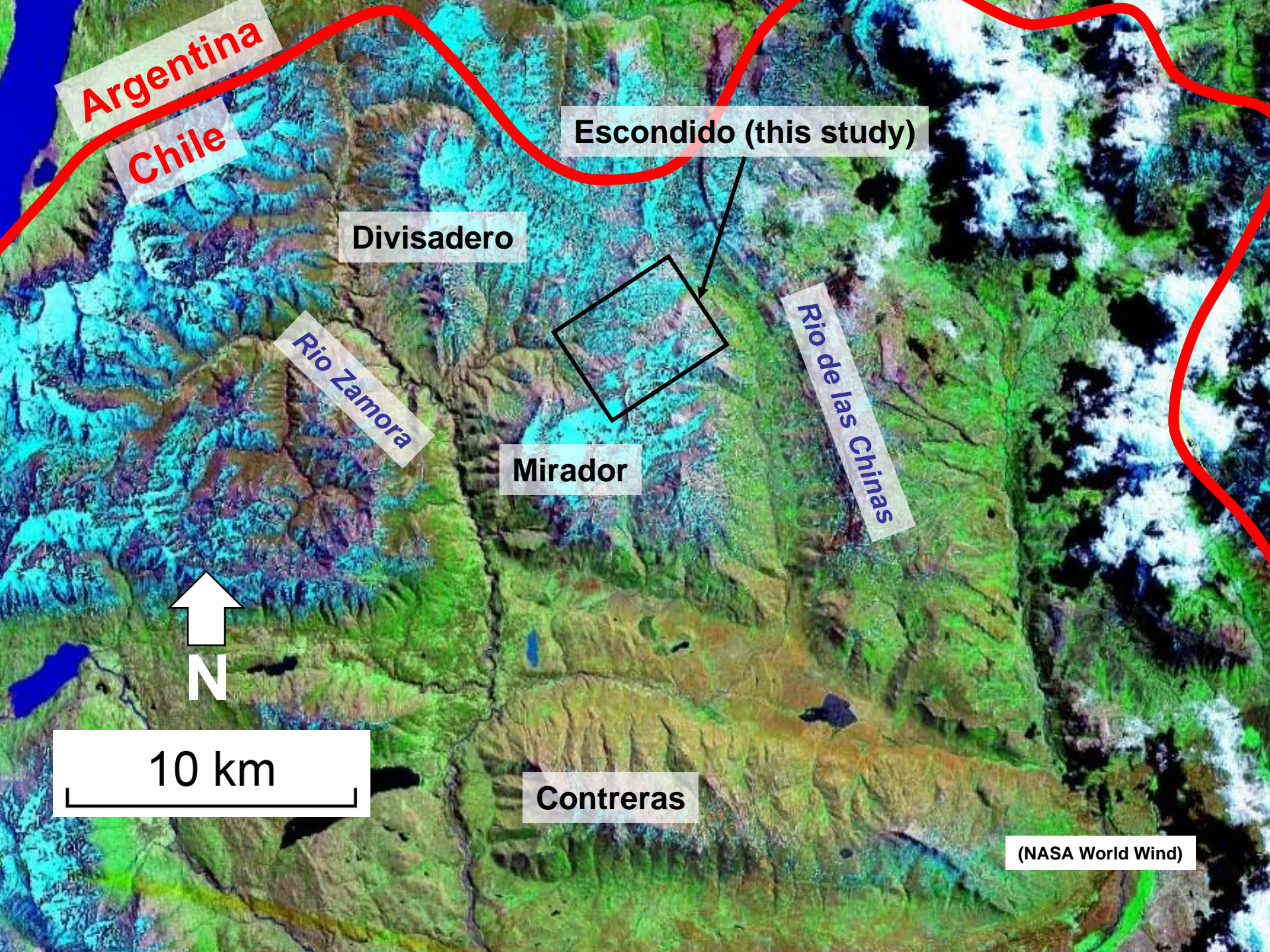
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Argentina

Chile

Escondido (this study)

Divisadero

Rio Zamora

Mirador

Rio de las Chinas



10 km

Contreras




(NASA World Wind)

Cerro Escondido: Depositional-strike view

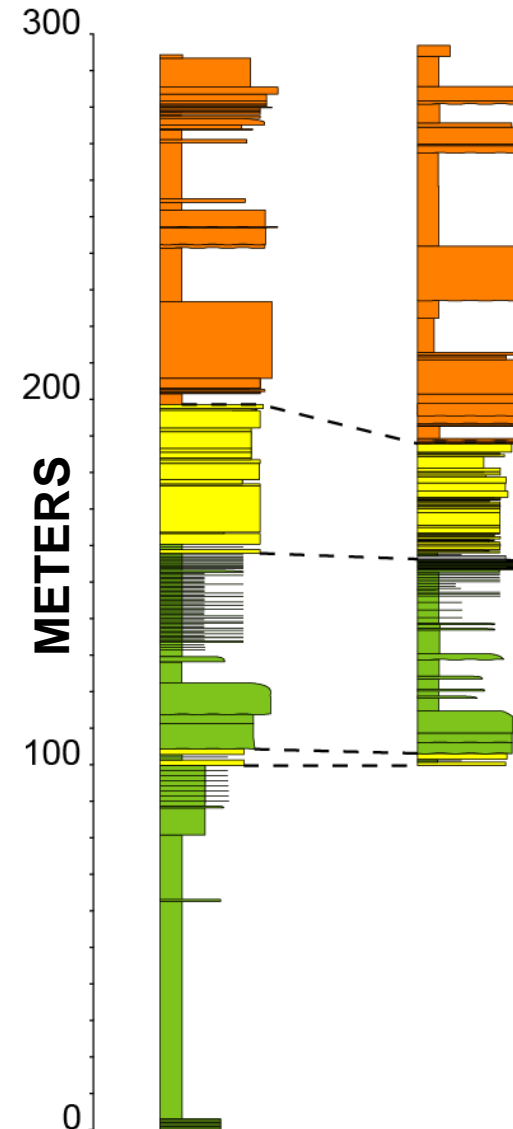
- 300 m thick
- >800 m wide
- South-directed paleocurrent






Stratigraphic architecture of Cerro Escondido

-  Lithofacies association 3:
Trough cross-stratified sandstone encased
in carbonaceous mudstone and siltstone
lithofacies
-  Lithofacies association 2:
Hummocky, overlain by swaley,
cross-stratified sandstone lithofacies
-  Lithofacies association 1:
Thick, amalgamated turbidites
interbedded with mudstone/siltstone
overlain by thinner turbidites

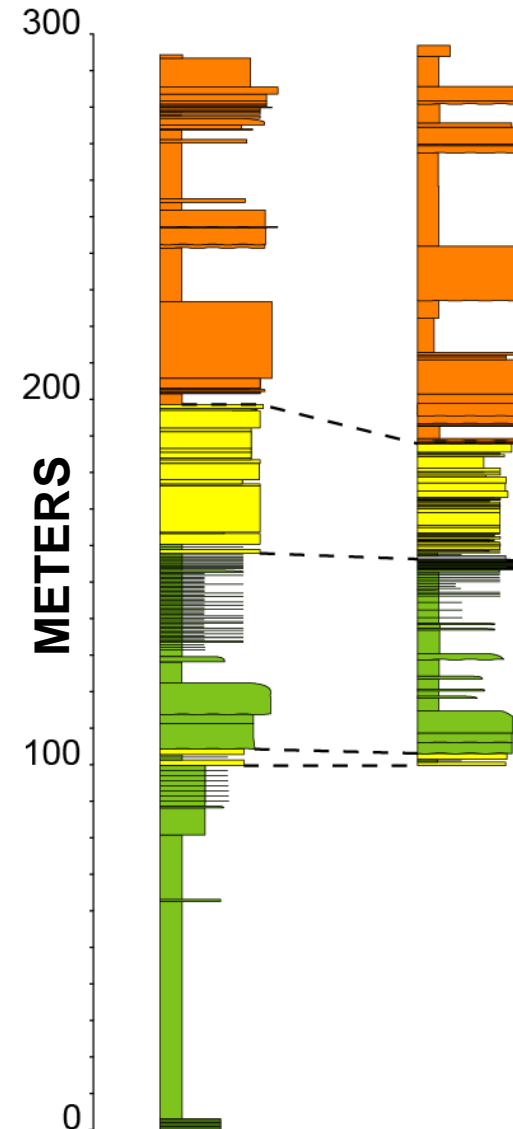
Generalized stratigraphy






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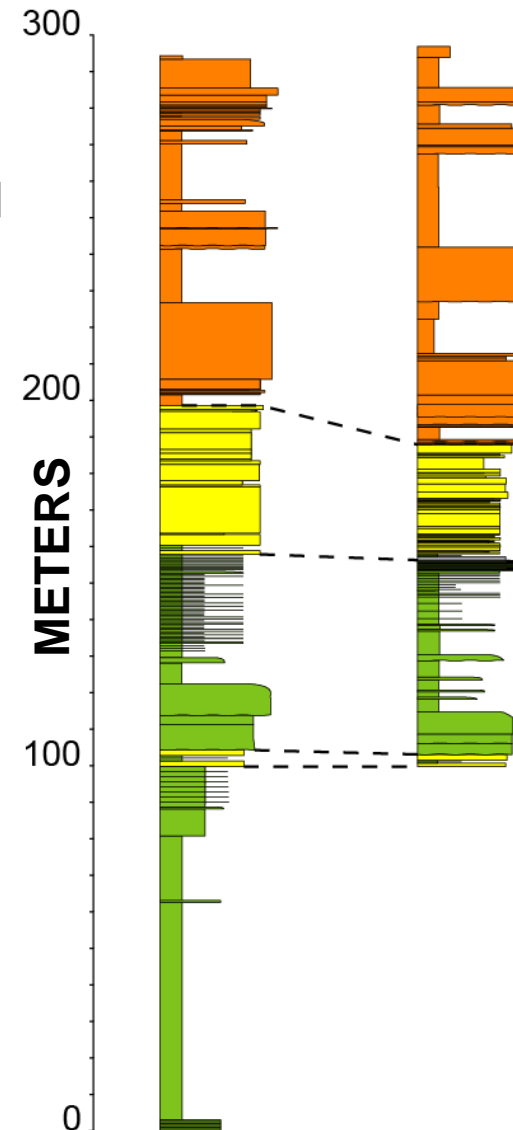
Generalized stratigraphy



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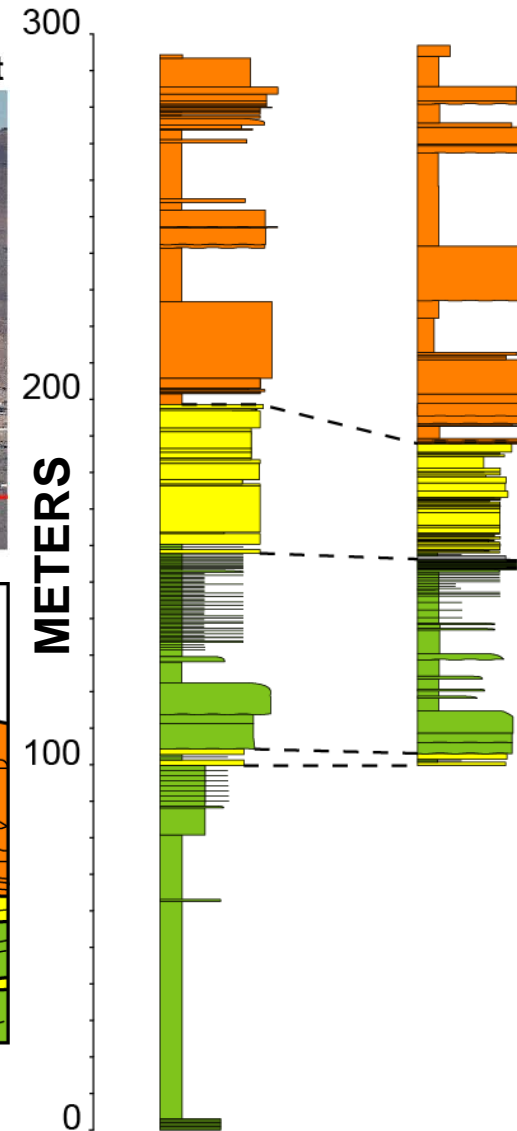
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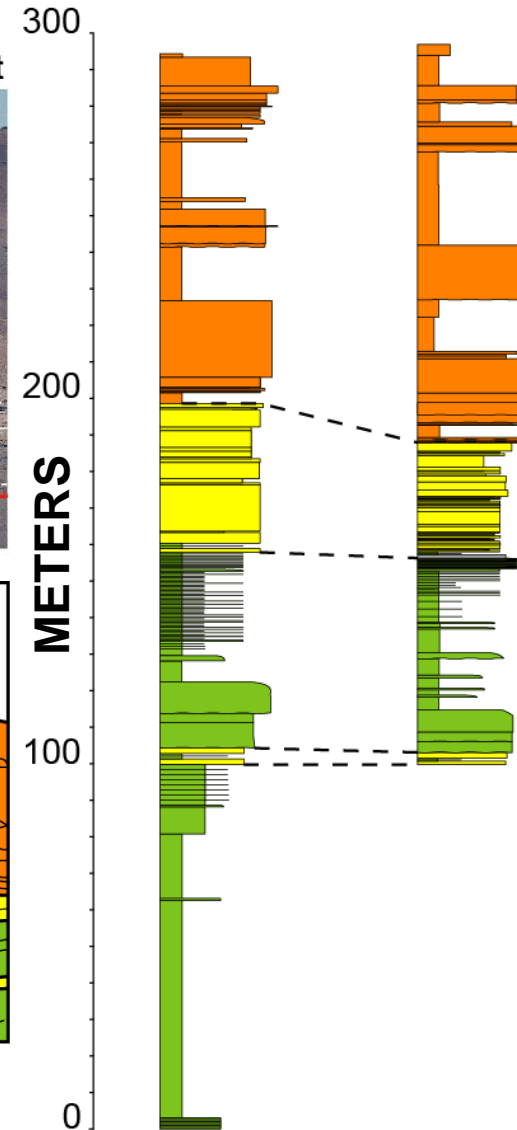
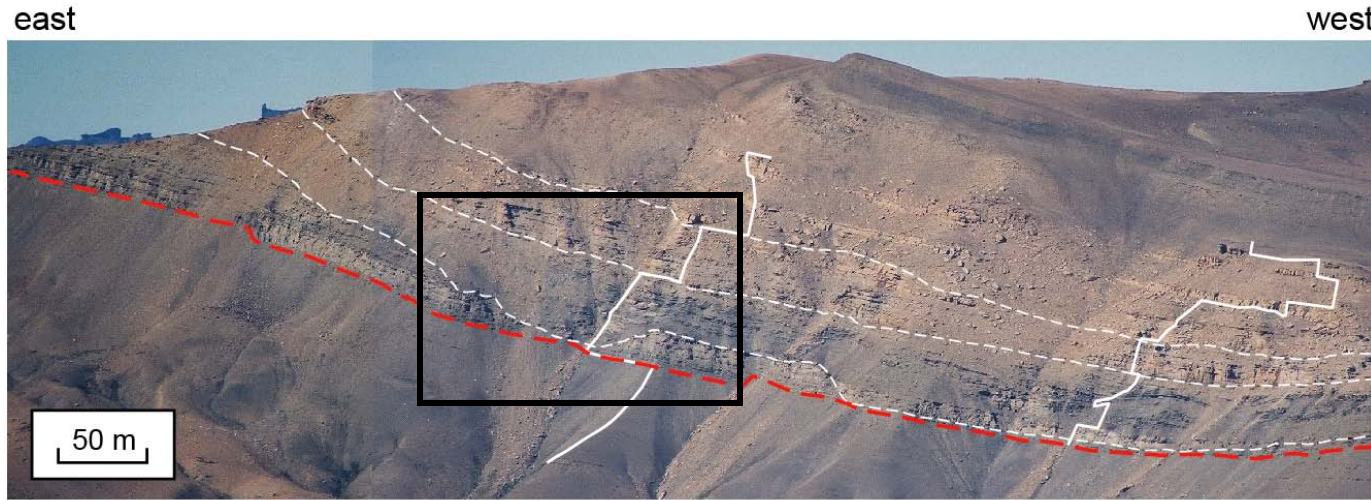
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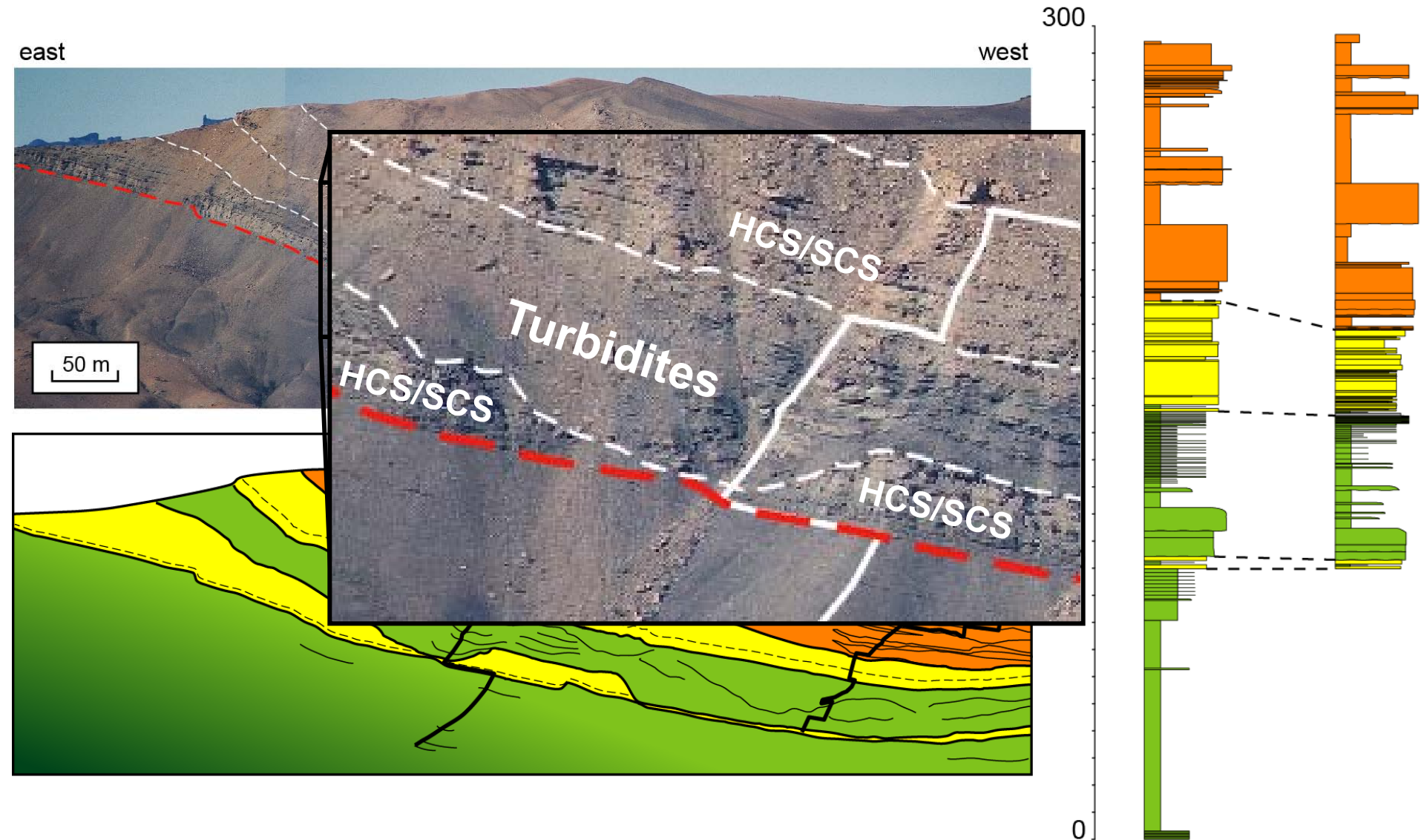
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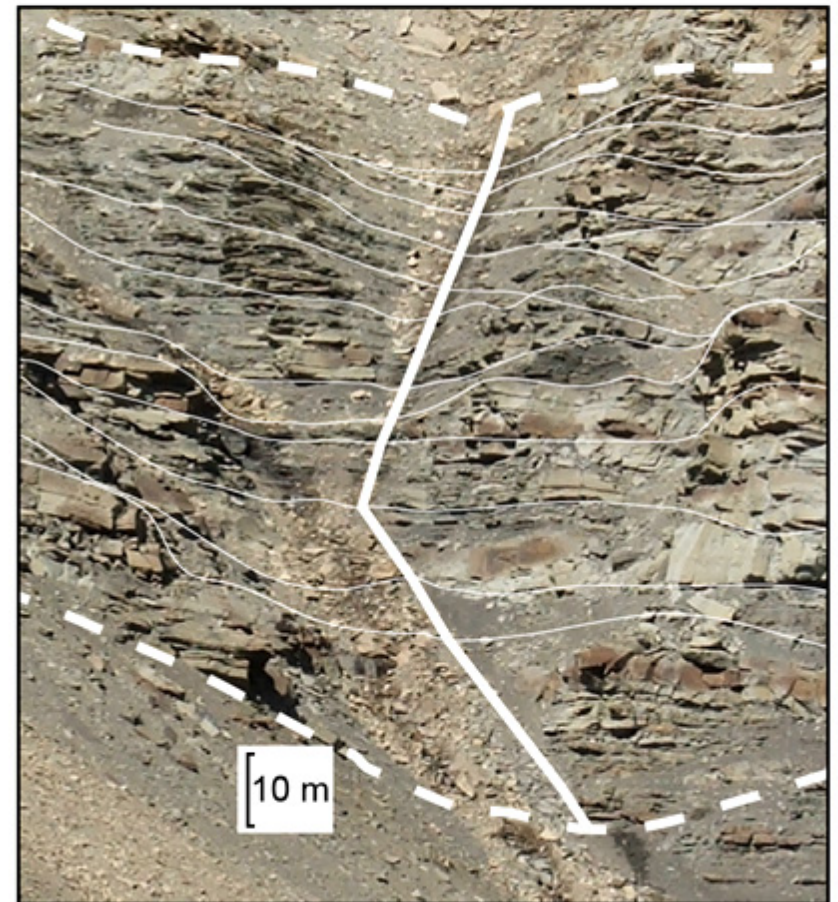
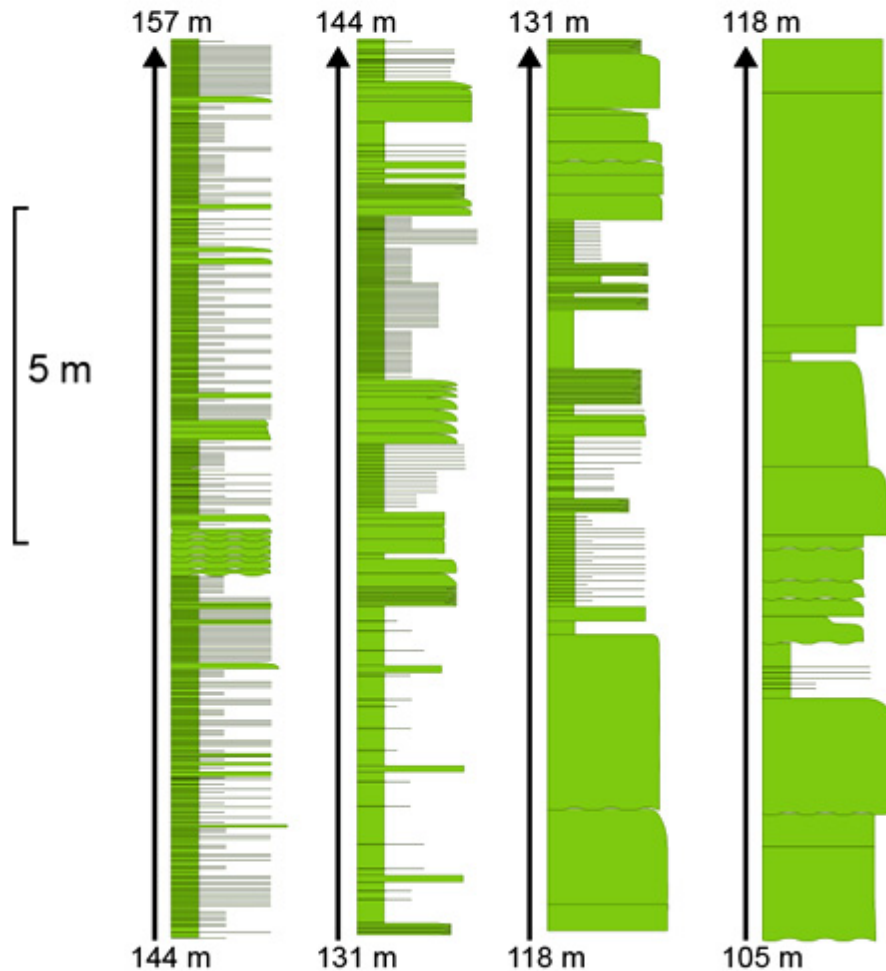


Significance of delta-front turbidites

Upward thinning, with a progressive increase in sand richness

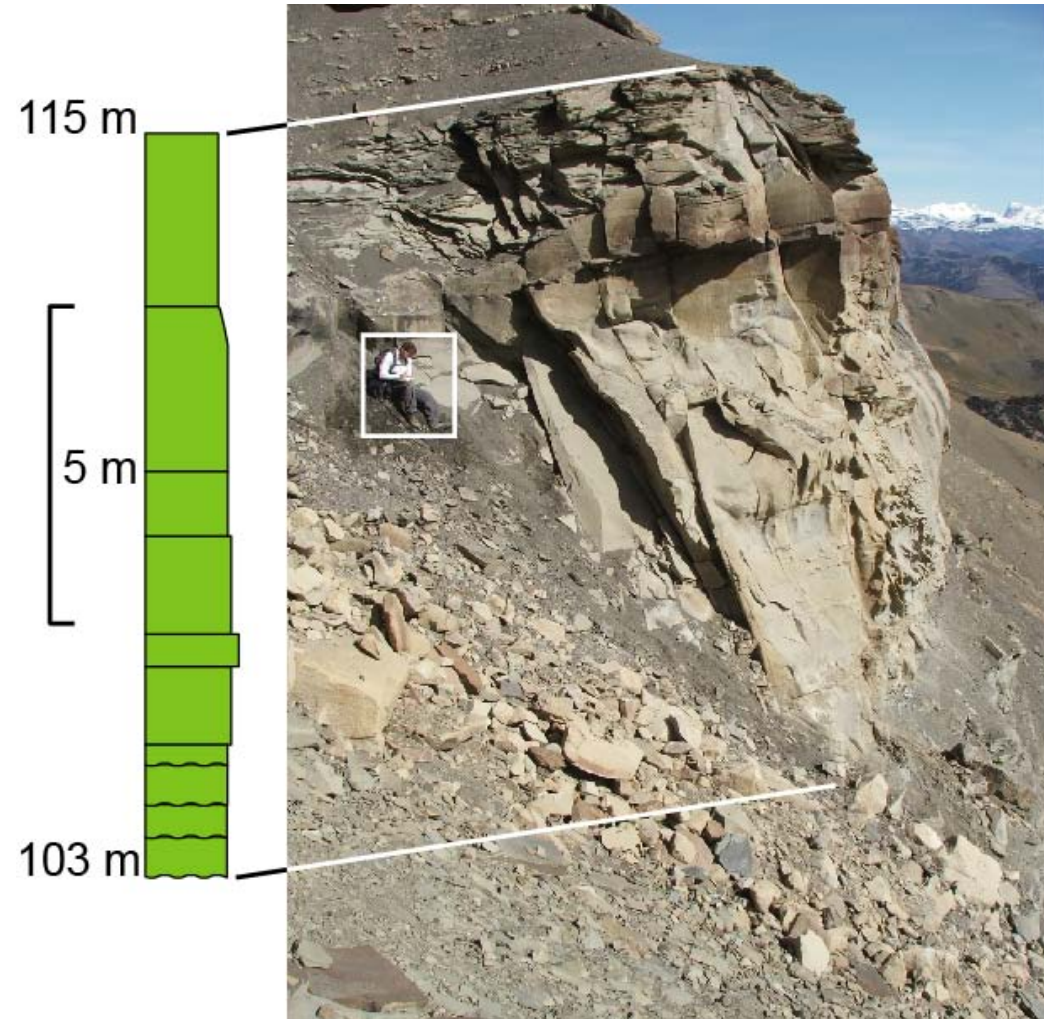
Increased occurrence of relatively frequent and dilute flows

Progradation (helps to have stratigraphic context of 'HCS/SCS sandwich')



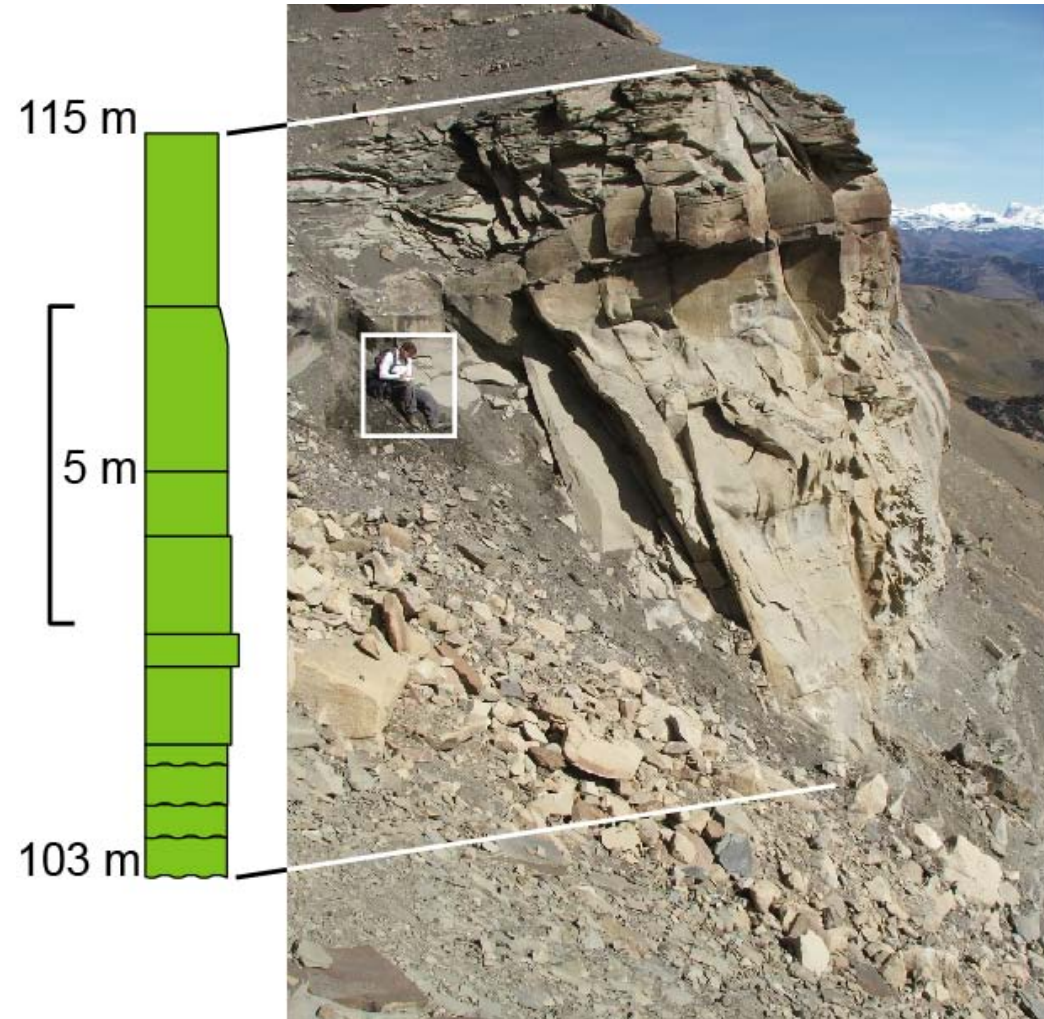
Lithofacies association 1: Turbidites

- Thicker, amalgamated beds
AND
mud/siltstone
sections near lithofacies
association base
- *Less frequent events/
large, dense flows
AND
fine-grained
background
sedimentation*



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Lithofacies association 1: Turbidites

- Thinner beds near lithofacies association top
- *Frequent events/small, dilute flows*



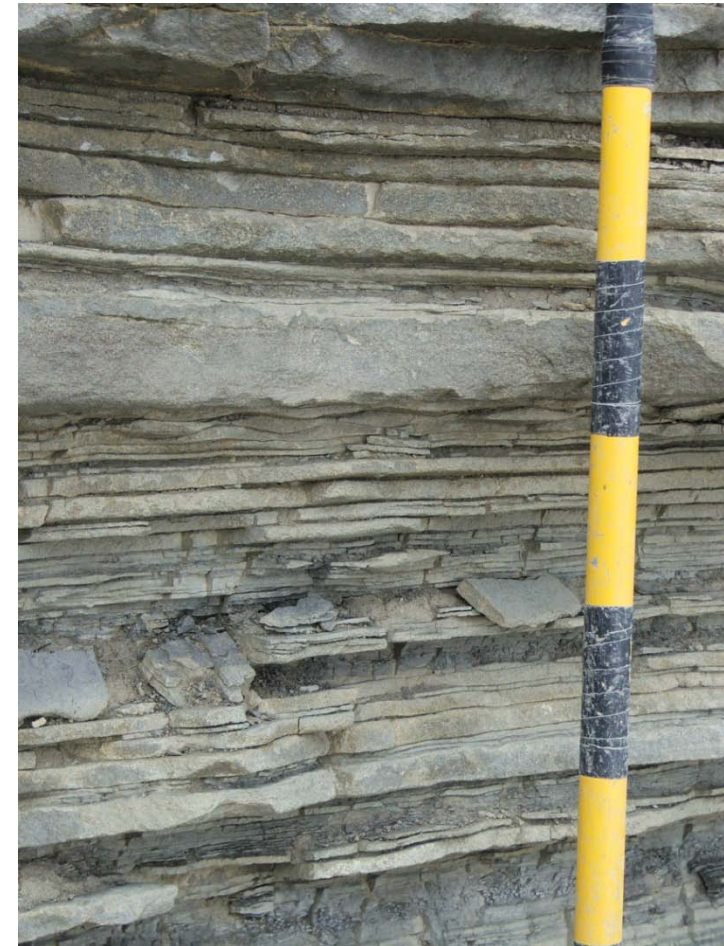
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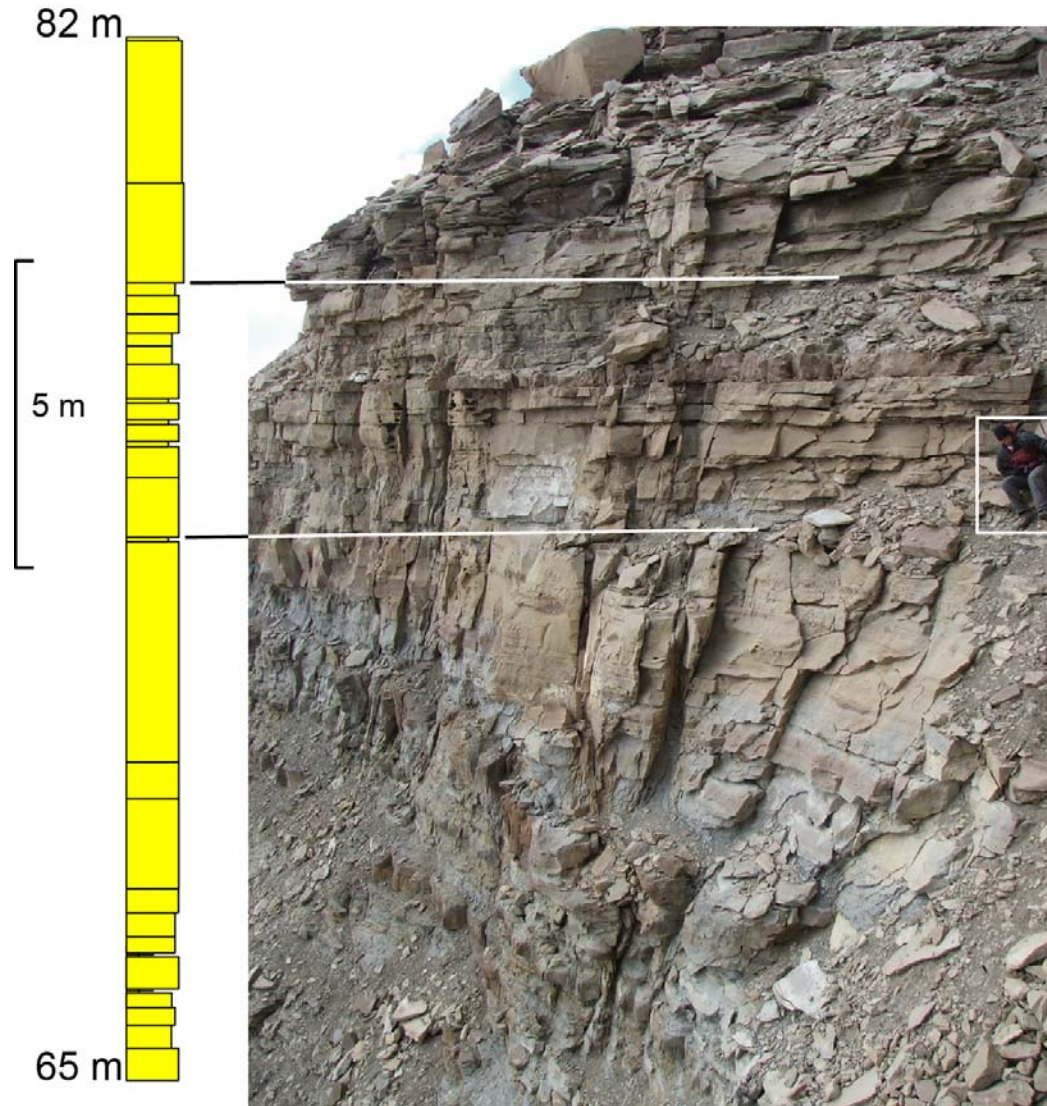
Lithofacies association 1: Turbidites

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Lithofacies association 2: HCS and SCS

- Hummocky to swaley cross-stratified sandstone

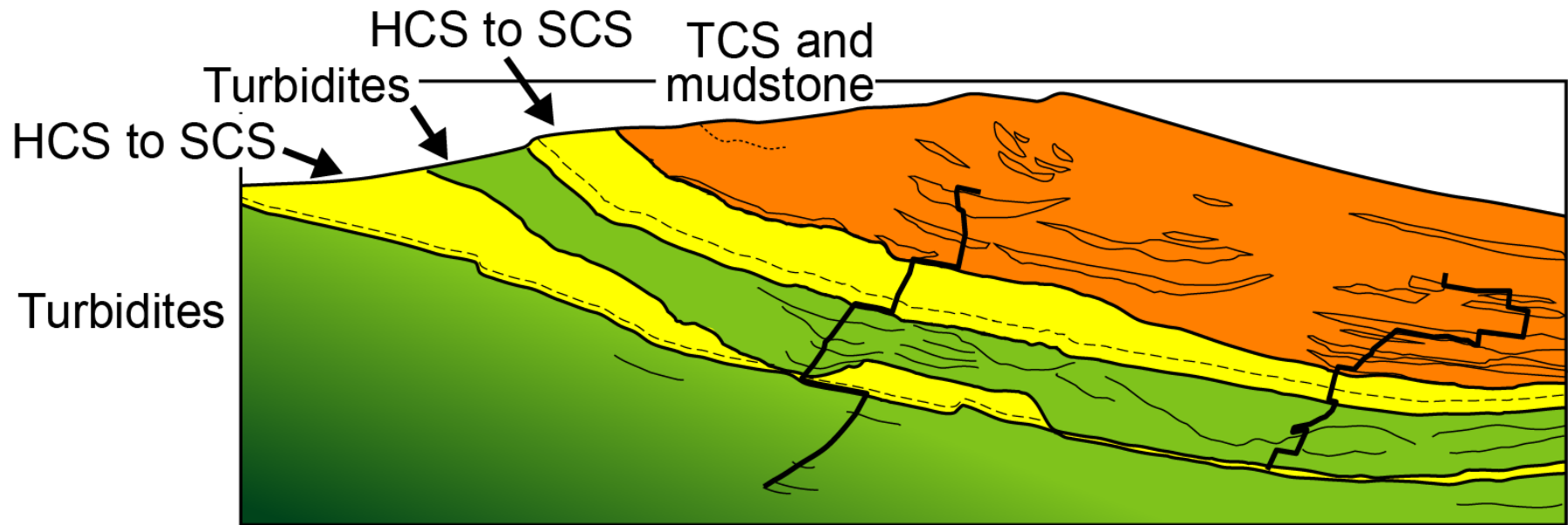


Lithofacies association 2: HCS and SCS

- Swaley cross-stratified sandstone beds

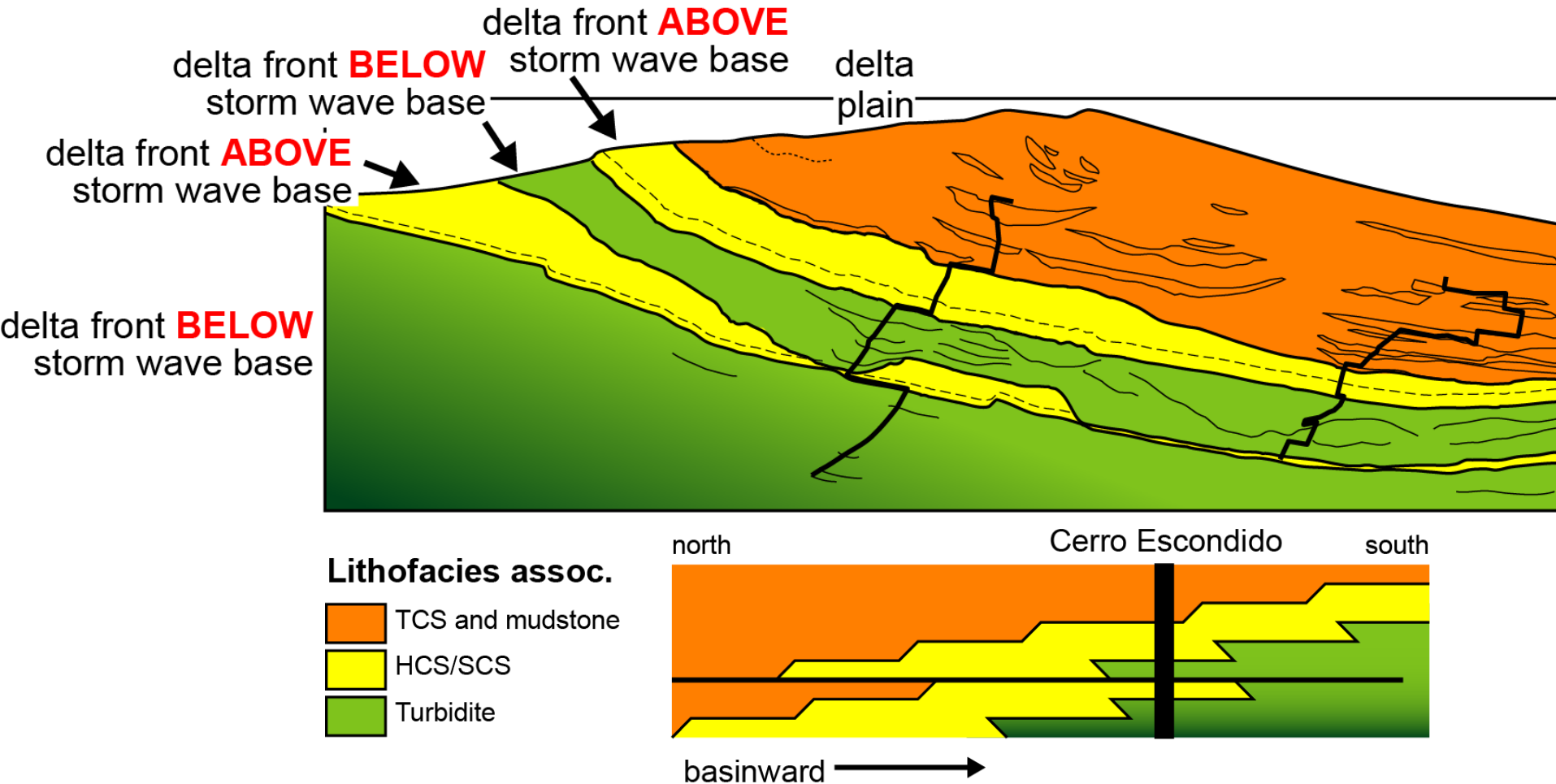


Stratigraphic architecture of Cerro Escondido



Stratigraphic architecture of Cerro Escondido

- Paleoenvironmental interpretation

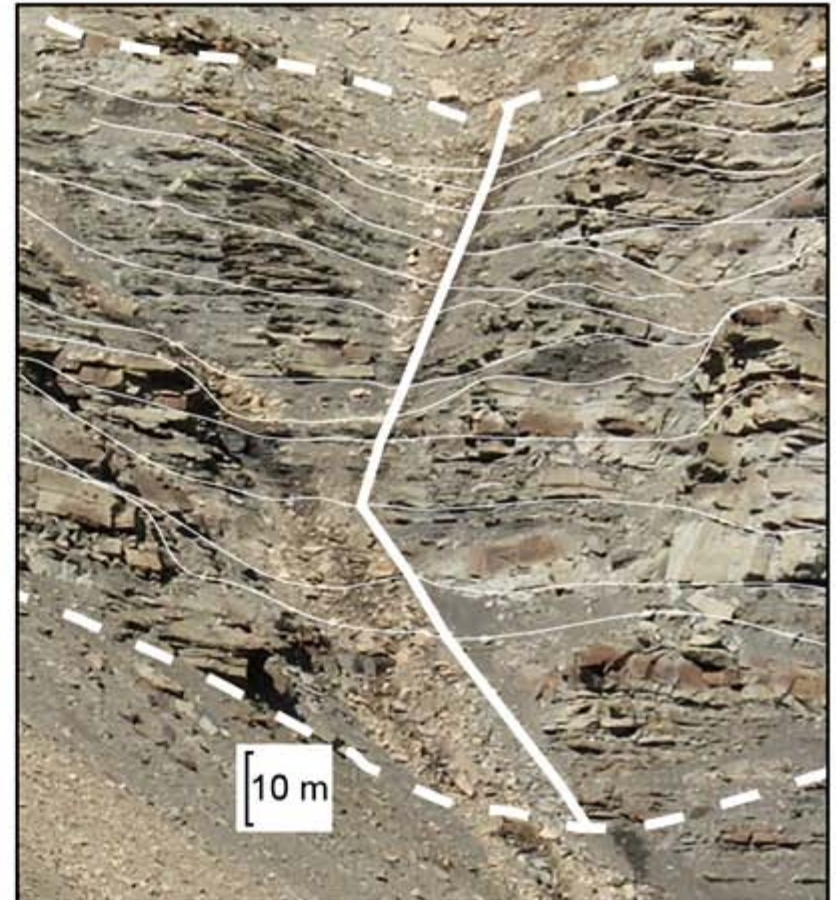
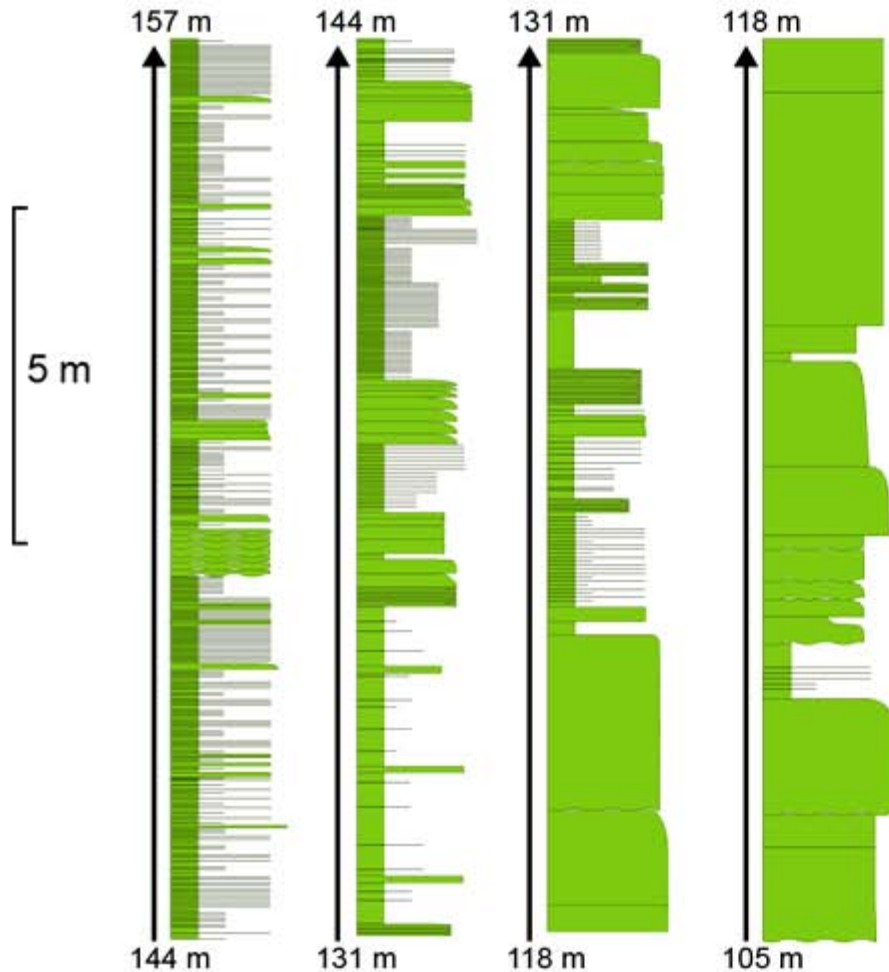


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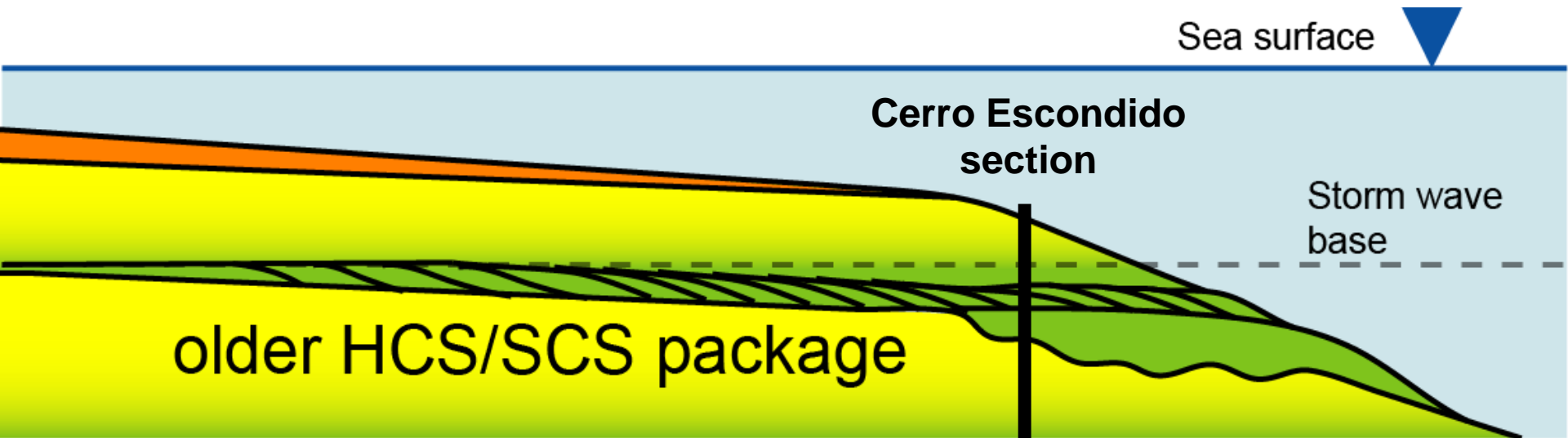
Increased occurrence of relatively frequent and dilute flows

Progradation (helps to have stratigraphic context of 'HCS/SCS sandwich')



Significance of turbidites in shelf-slope construction

- More frequent initiation events and as a result, higher density flow



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 - New insight into down- and up-dip lithofacies distributions

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Acknowledgements

- Andrea Fildani
- Steve Hubbard
- Ralph Hinsch (RAG)

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SPODDS

Stanford Project On Deepwater Depositional Systems



MAERSK OIL



Husky Energy



AERA

nexen



ExxonMobil

RELIANCE Energy



Anadarko
Petroleum Corporation

- **SPODDS** colleagues
 - Dom Armitage
 - Anne Bernhardt
 - Julie Fosdick
 - Zane Jobe
 - Don Lowe
 - Katie Maier
 - Chris Mitchell
 - Lisa Stright

References

Fildani, A. and A.M. Hessler, 2005, Stratigraphic record across a retroarc basin inversion: Rocas Verdes-Magallanes Basin, Patagonian Andes, Chile: GSA Bulletin, V. 117/11-12, p. 1596-1614; DOI: 10.1130/B25708.1

Hubbard, S.M., 2006, Deep-sea foreland basin axial channels and associated sediment gravity flow deposits, Oligocene Molasse basin, Upper Austral, and Cretaceous Magallanes basin, Chile: PhD. Thesis Stanford University, Department of Geological and Environmental Sciences, 216 p.