



Università degli studi di Trieste

LAUREA MAGISTRALE IN GEOSCIENZE

Classe Scienze e Tecnologie Geologiche

Curriculum: Esplorazione Geologica

Anno accademico 2025 - 2026

Analisi di Bacino e Stratigrafia Sequenziale (426SM)

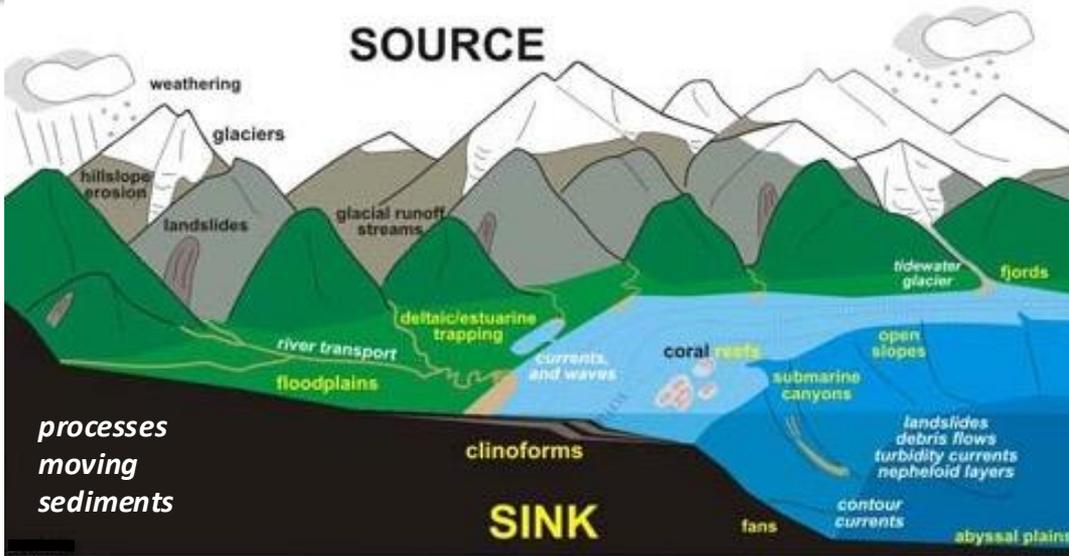
Docente: **Michele Rebesco**



Unit 3.4
Continental Slope:
Sediementary structures
associated to gravit flows
Teacher: **Renata G. Lucchi**

OUTLINE

- The source to sink system
- Continental slope types and key features
- Continental slopes at high latitude margins (TMFs, gullies, channels)
- Continental slopes at mid latitude margins (canyon-channel-deep sea fans systems)
- Identifying submarine landslides and debris flows



the Source to Sink System

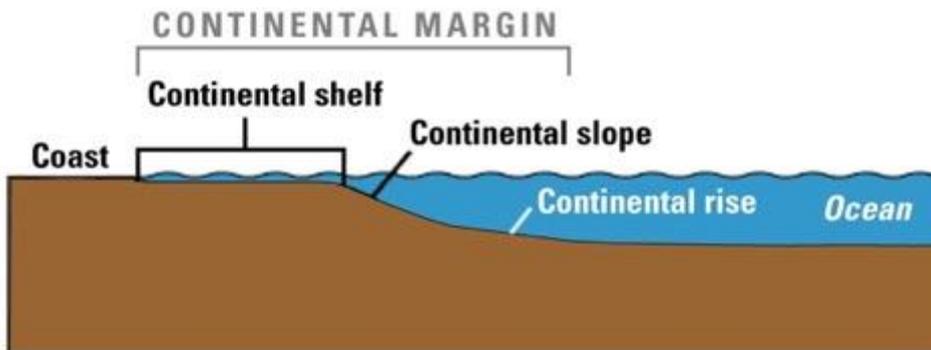


Sedimentary Processes on Continental Margins

down-slope: driven by gravity forces

along-slope: driven by density forces

(thermo-haline or water mass accumulation)



Continental shelf

Preferential area of sediment accumulation
High sediment accumulation

High isostatic subsidence

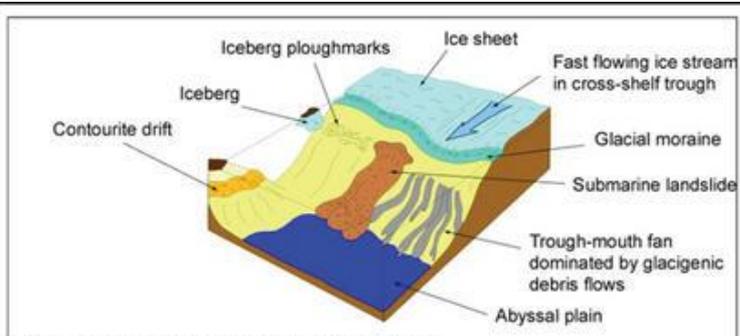
Continental slope sediment deposition and transfer toward deeper environments

Continental rise: sediment deposition (deep sea fans, sediment drifts)

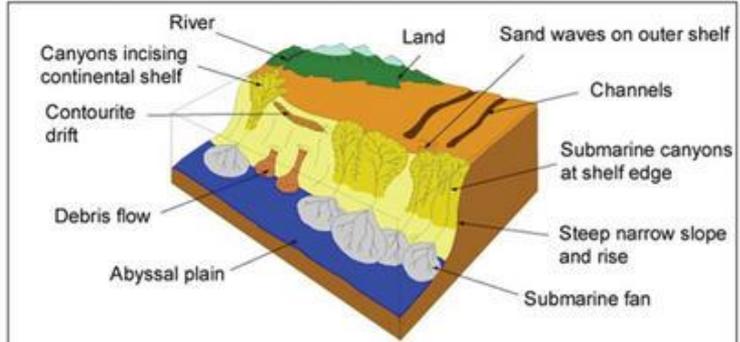
High latitude

Mid latitude

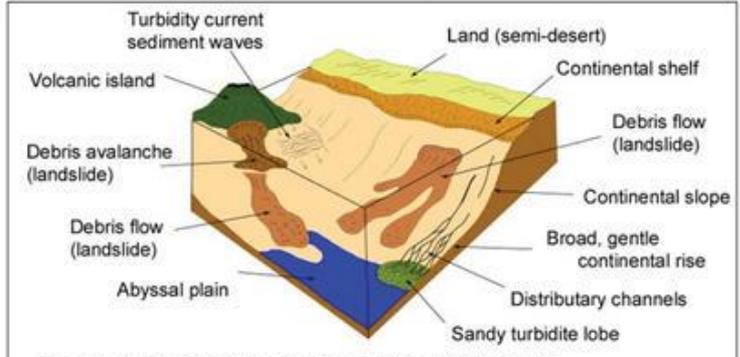
Low latitude



GLACIAL PROCESSES
(dominated by glacial debris flows and landslides)
(diagram shows processes operating in glacial times)



RIVER PROCESSES
(dominated by canyons and channels)



STARVING AREAS
(dominated by landslide processes)

Continental slope types and related distinctive sedimentary features

GLACIAL INFLUENCES MARGINS

- Gullies (rare canyons)
- Trough Mouth Fans (TMF)
- Submarine landslides

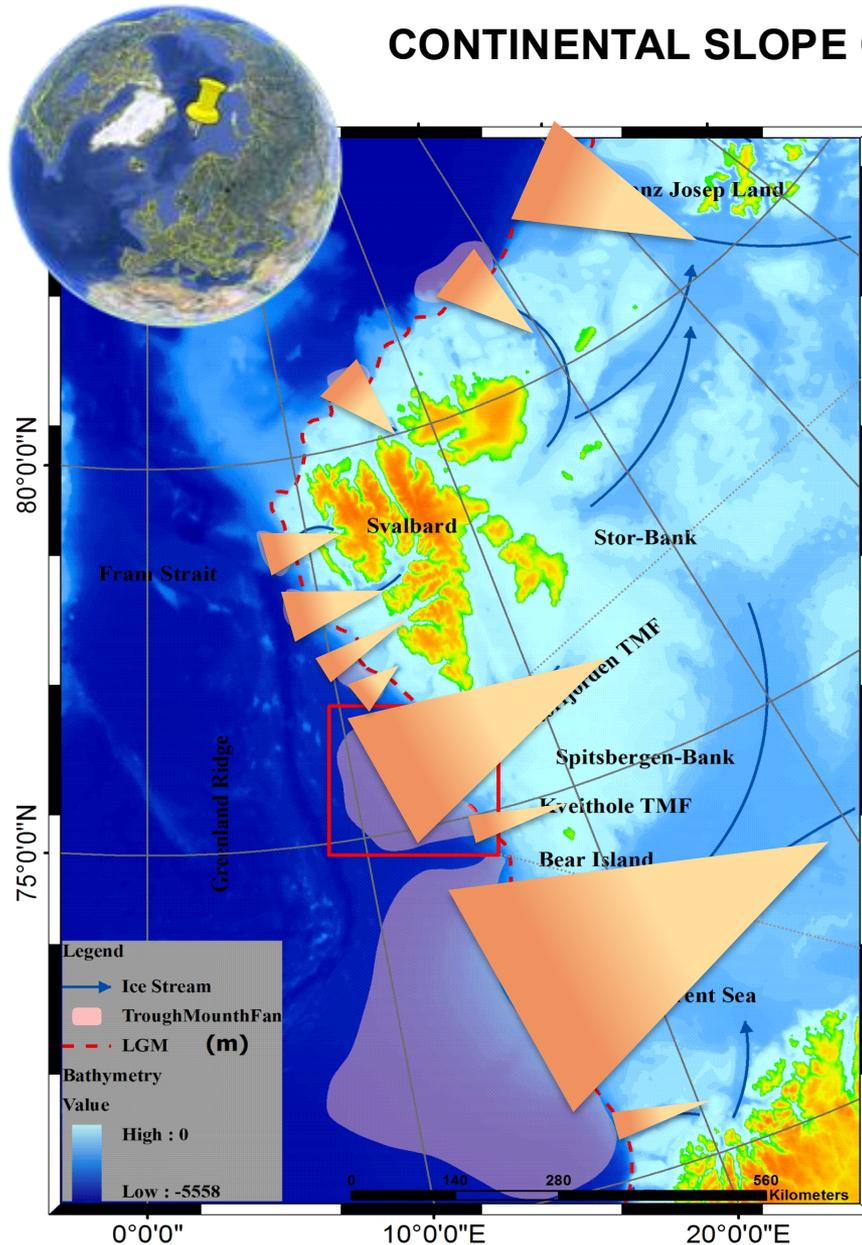
RIVER INFLUENCES MARGINS

- Well developed canyon-channel-deep sea fan systems
- Submarine landslides

SEDIMENT STARVING MARGINS

- Submarine landslides
- Mass gravity deposition

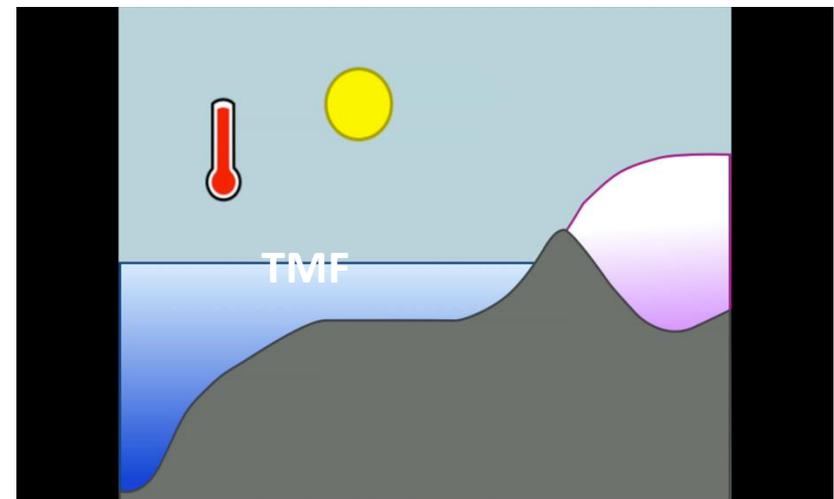
CONTINENTAL SLOPE ON GLACIATED MARGINS

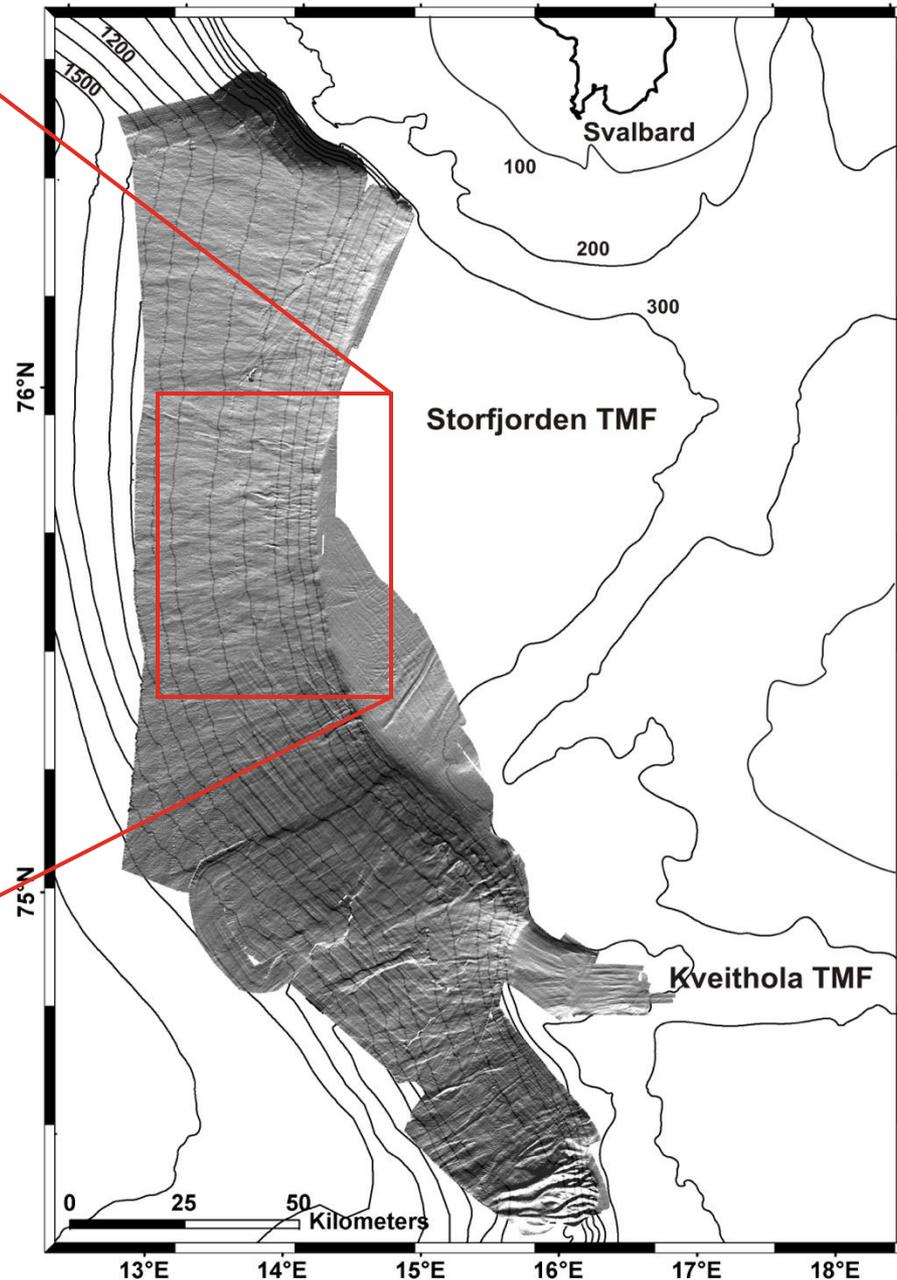
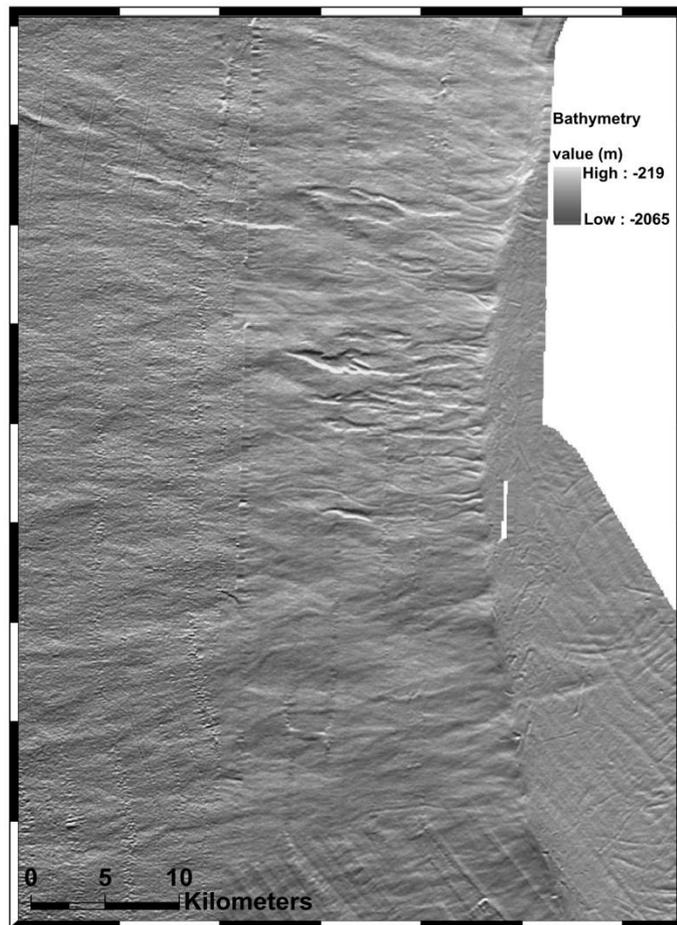


Ice Streams= Correnti di ghiaccio

Glacial trough= Fosse glaciali

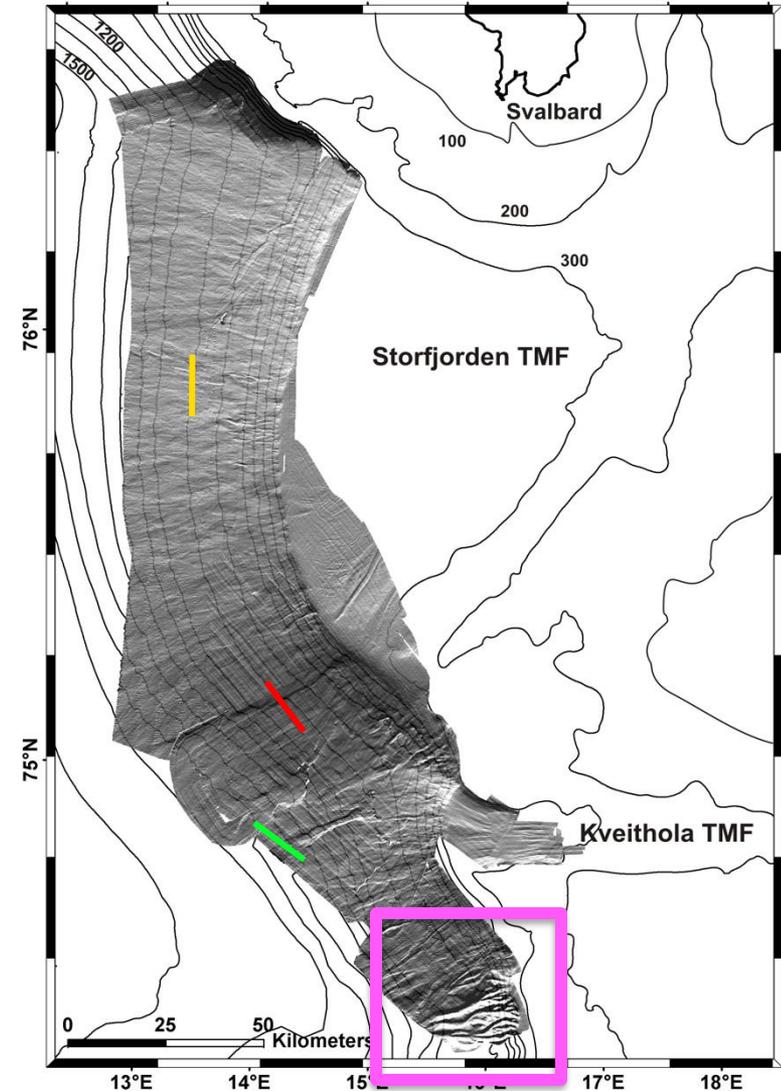
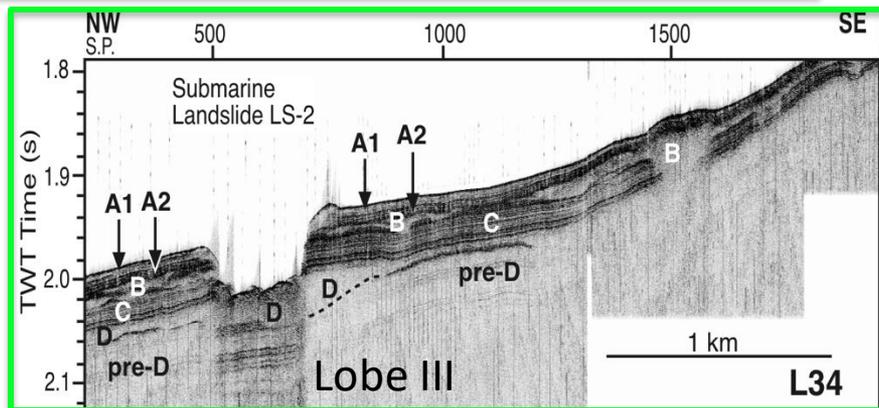
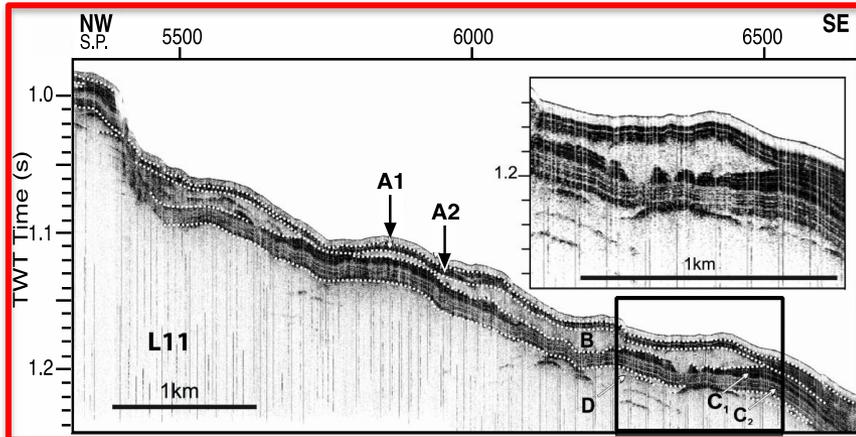
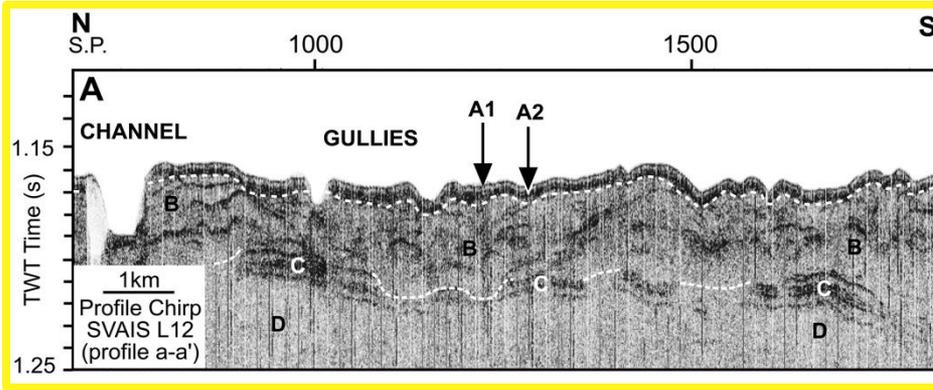
Trough Mouth Fans (TMFs)= Conoidi alla bocca della fossa glaciale



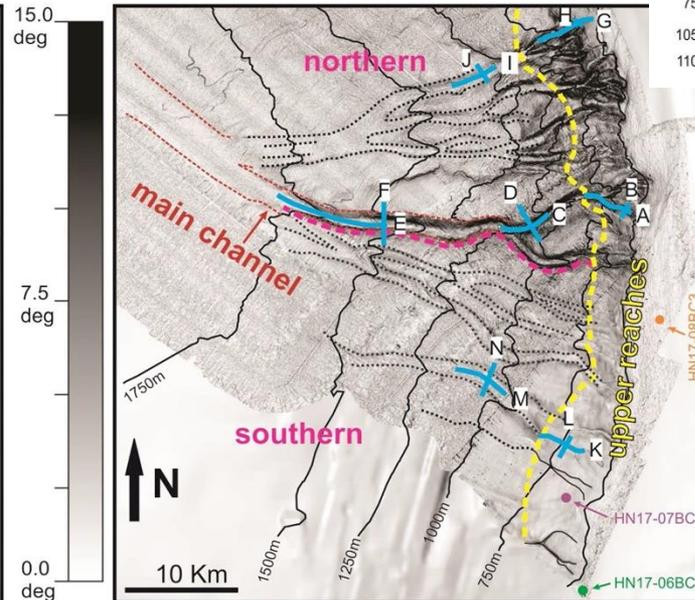
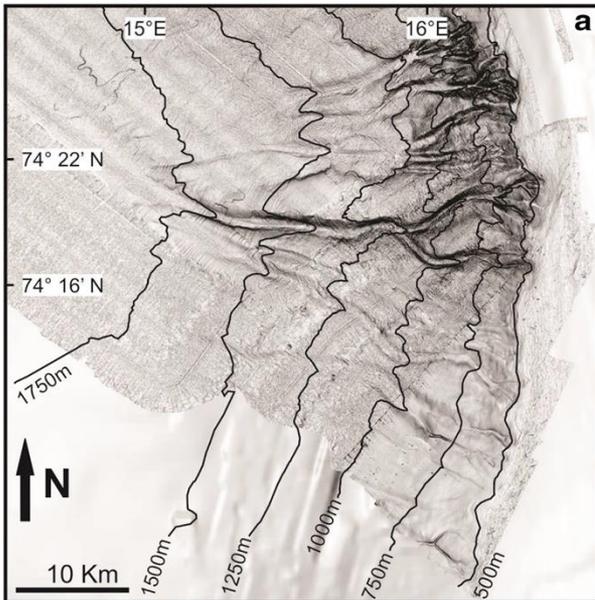
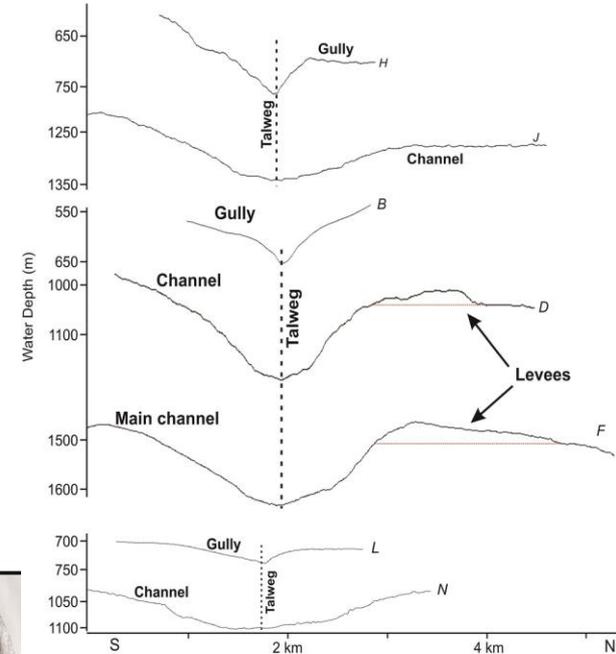
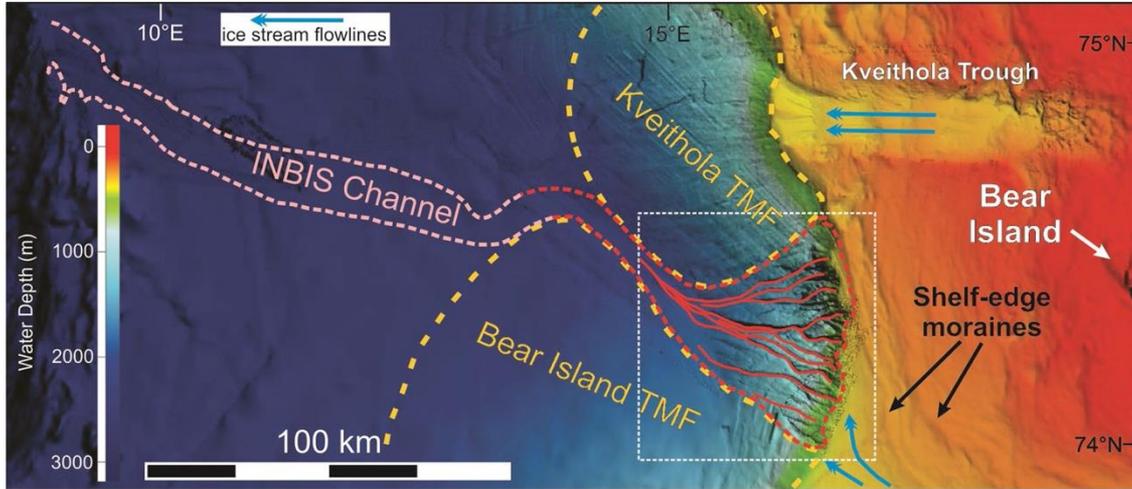


- Gullies (a few 10s m deep, a few 10s m large a few km long)
- Channels deriving from coalescent gullies
- Debris mounds
- Landslides

Continental slope architecture

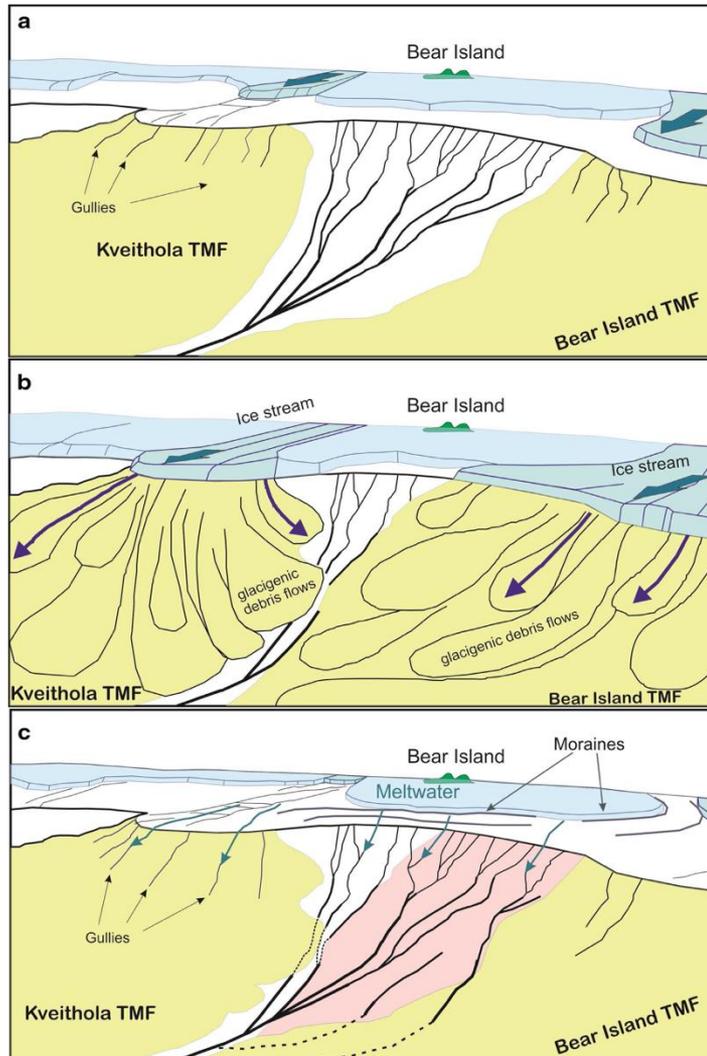


IN-Between-Ice Seets (INBIS) Channel



Gullies and Channels down-slope cross profiles

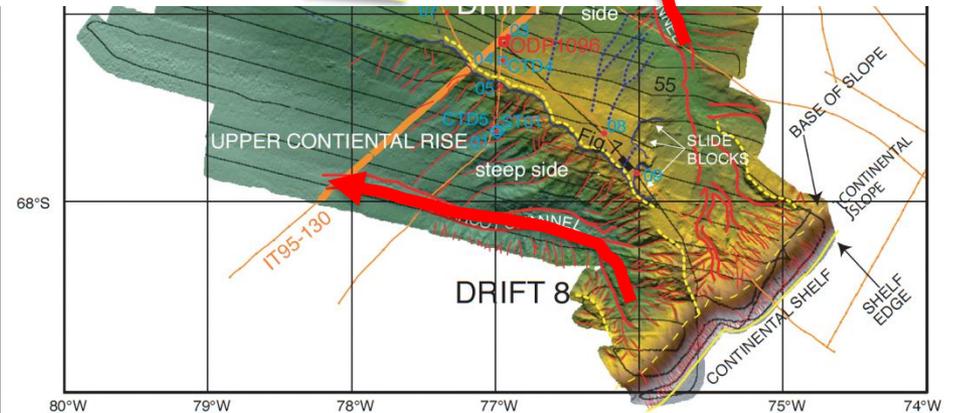
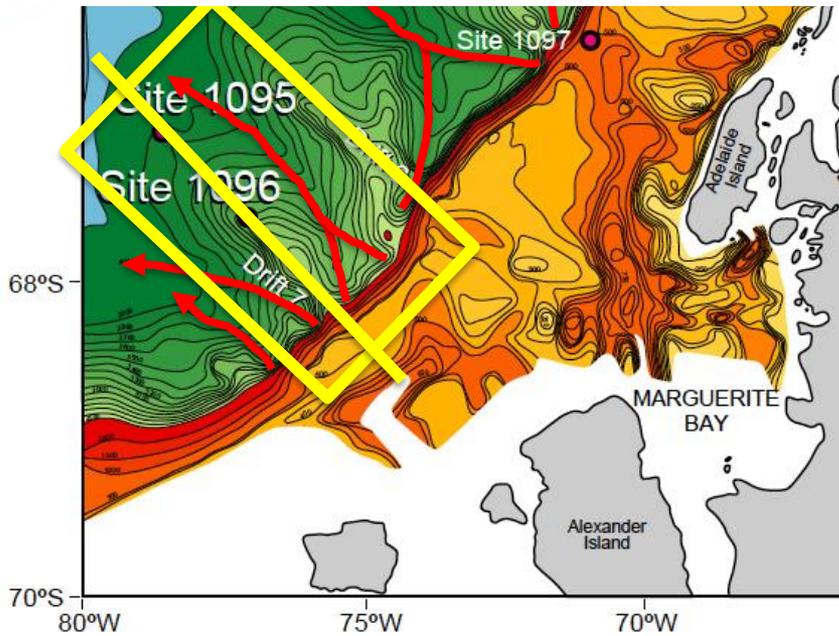
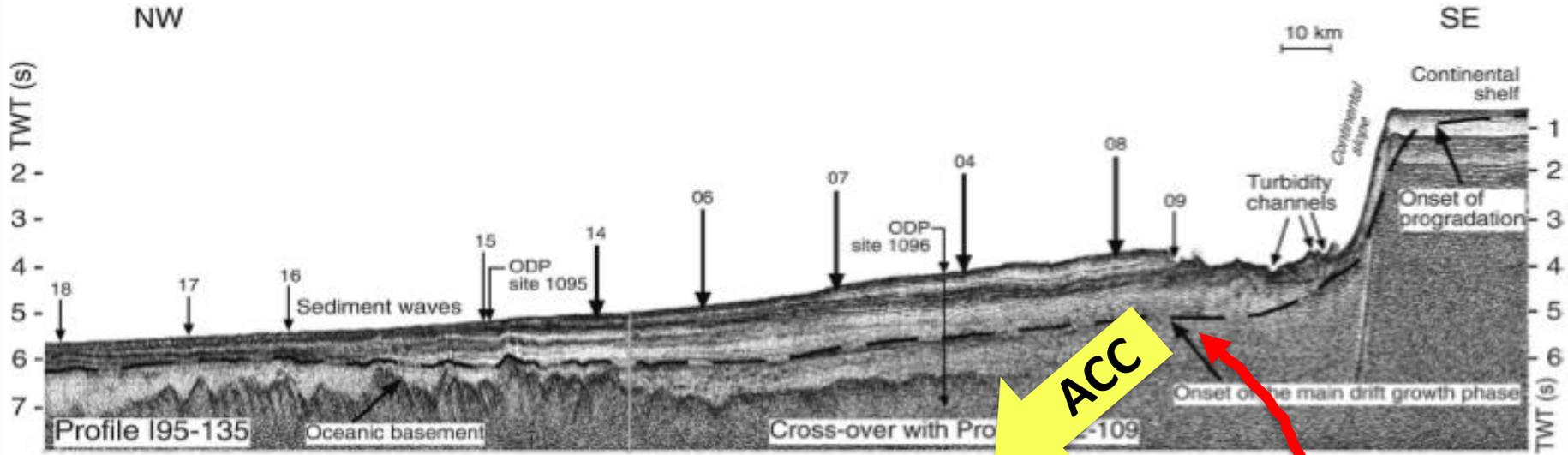
IN-Between-Ice Seets (INBIS) Channel temporal evolution



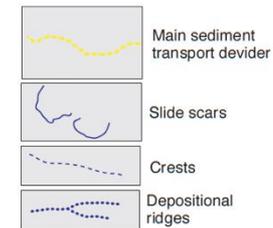
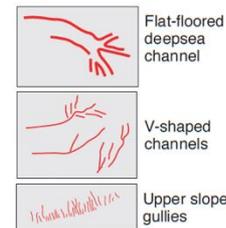
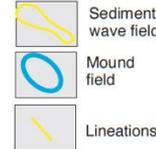
(a) pre-Last Glacial Maximum (LGM), slope sedimentation derived by pelagic settling and contour bottom currents

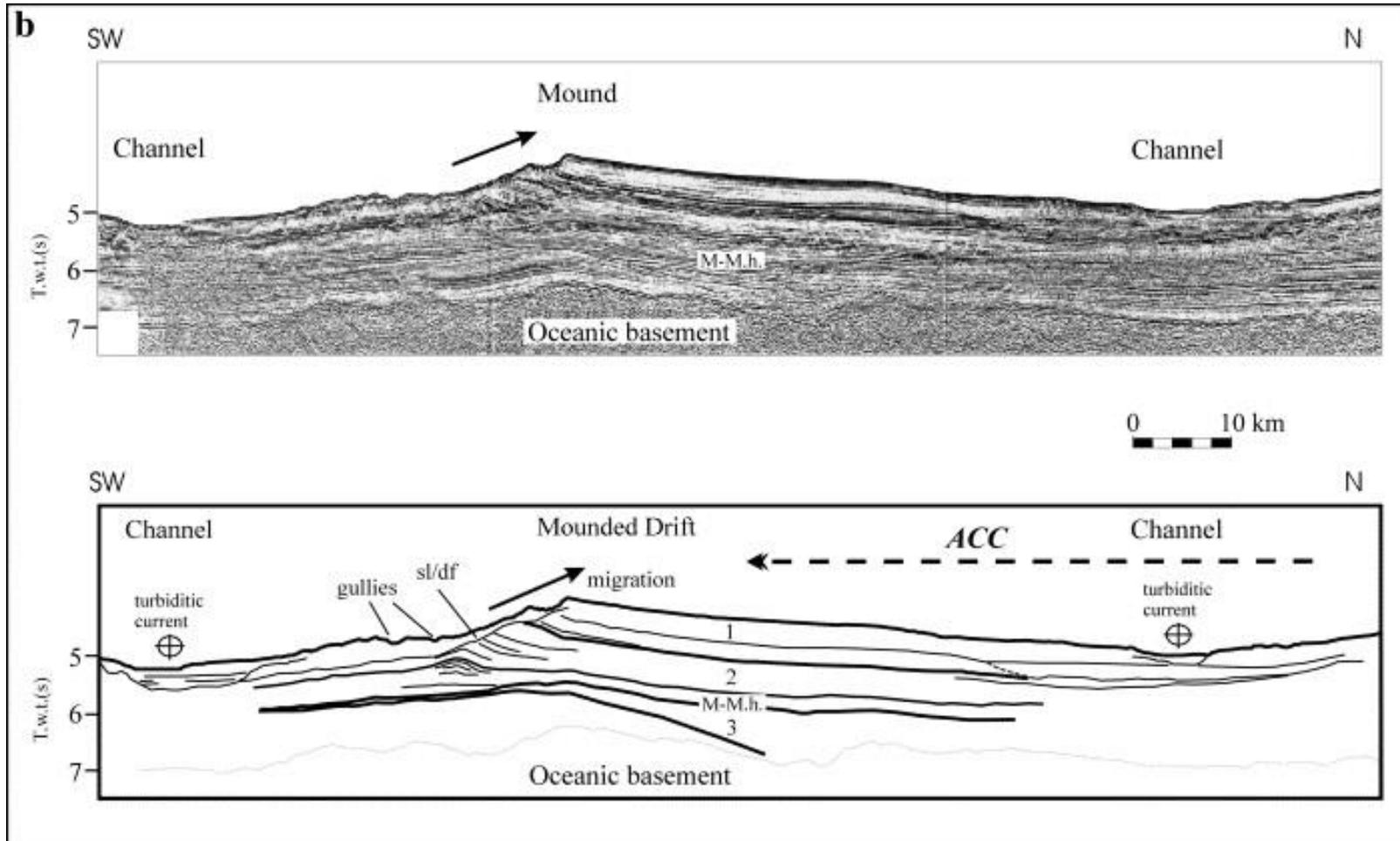
(b) LGM state with emplacement of glacialic debrites forming depositional mounds (or lobes)

(c) post-LGM state with high-energy jet flows derived from ice sheet melting caving new gullies at the shelf break and uppercontinental slope.



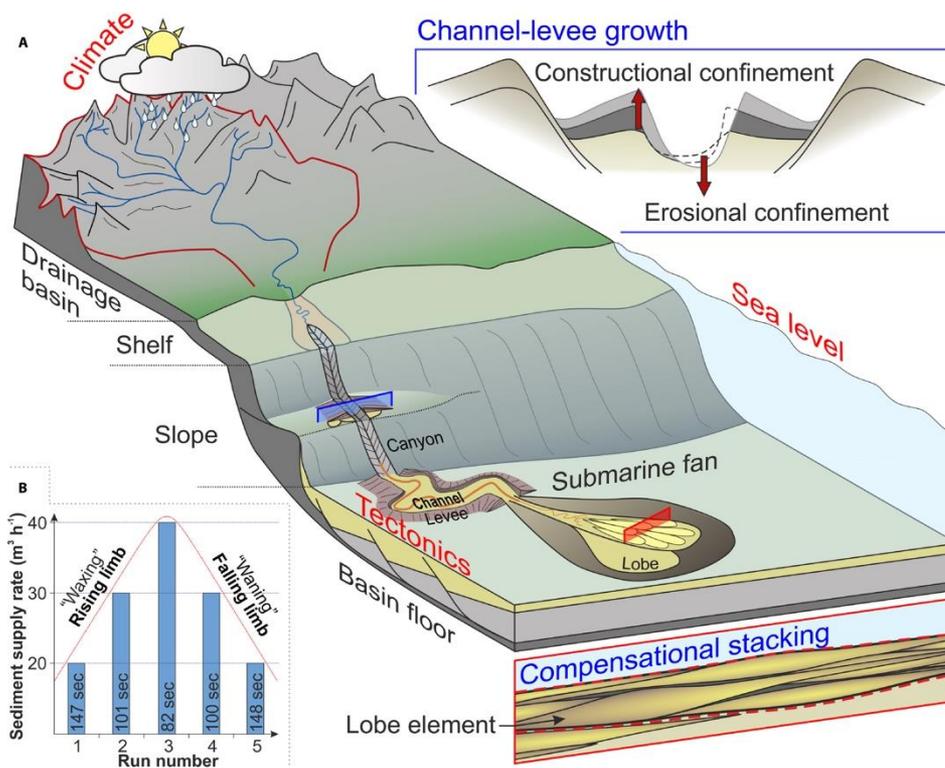
LEGEND





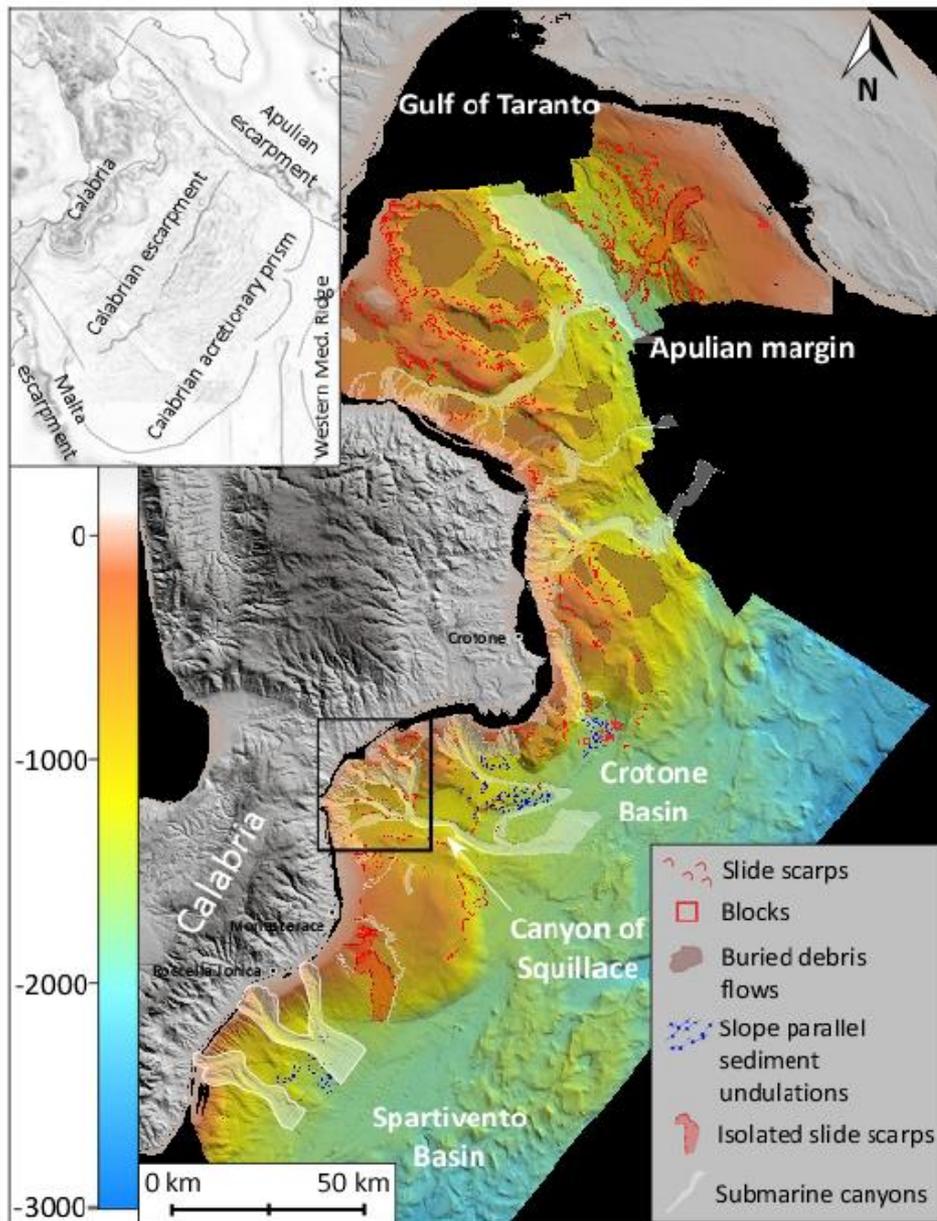
SLOPE SEDIMENTARY CONDUITS ON MID-LATITUDE MARGINS: CANYONS - CHANNELS - GULLIES

Submarine canyons and channels are **conduits** through which **sediments** are **transported across continental margins to deep-sea basins** by sediment gravity flows and other mass movements (Shepard, 1948, 1981; Menard, 1955).



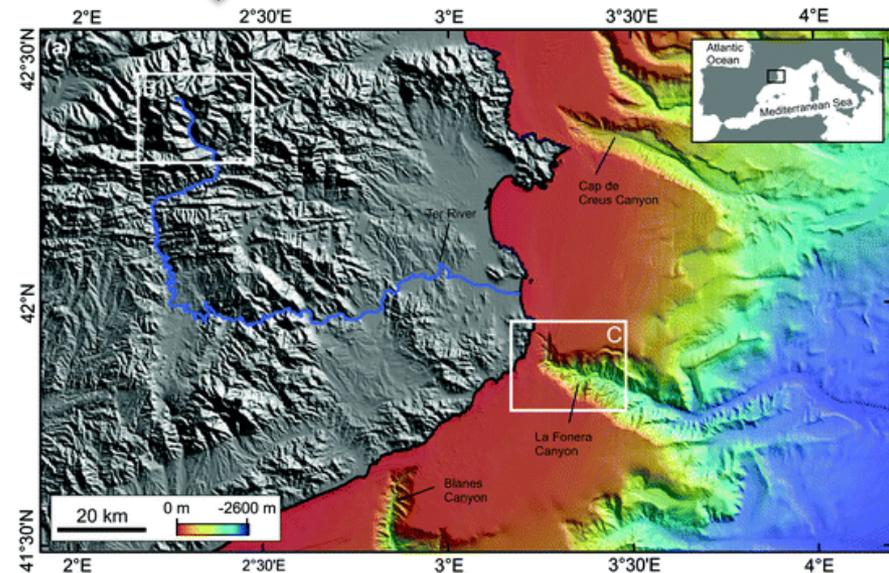
Submarine canyon: narrow steep-sided valleys cutting into continental slopes and rises. They can originate either within continental slopes or on continental shelves.

- Erosive or by-pass areas
- High gradient, strait conduit
- V-shaped cross profile with steep, rocky side walls 1000s m high (Grand Bahama Canyon 5 km)
- Side walls often intersected by erosive gullies
- 10s km wide
- 10s-100s km long

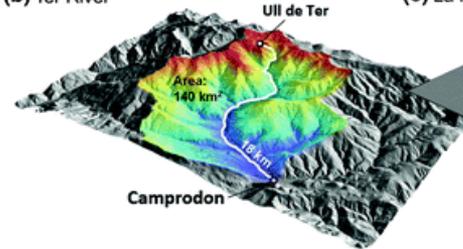


← Margine ionico della Calabria

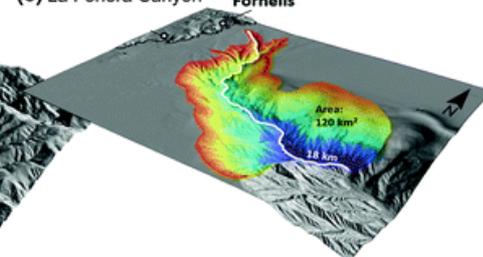
↓ Margine Catalano



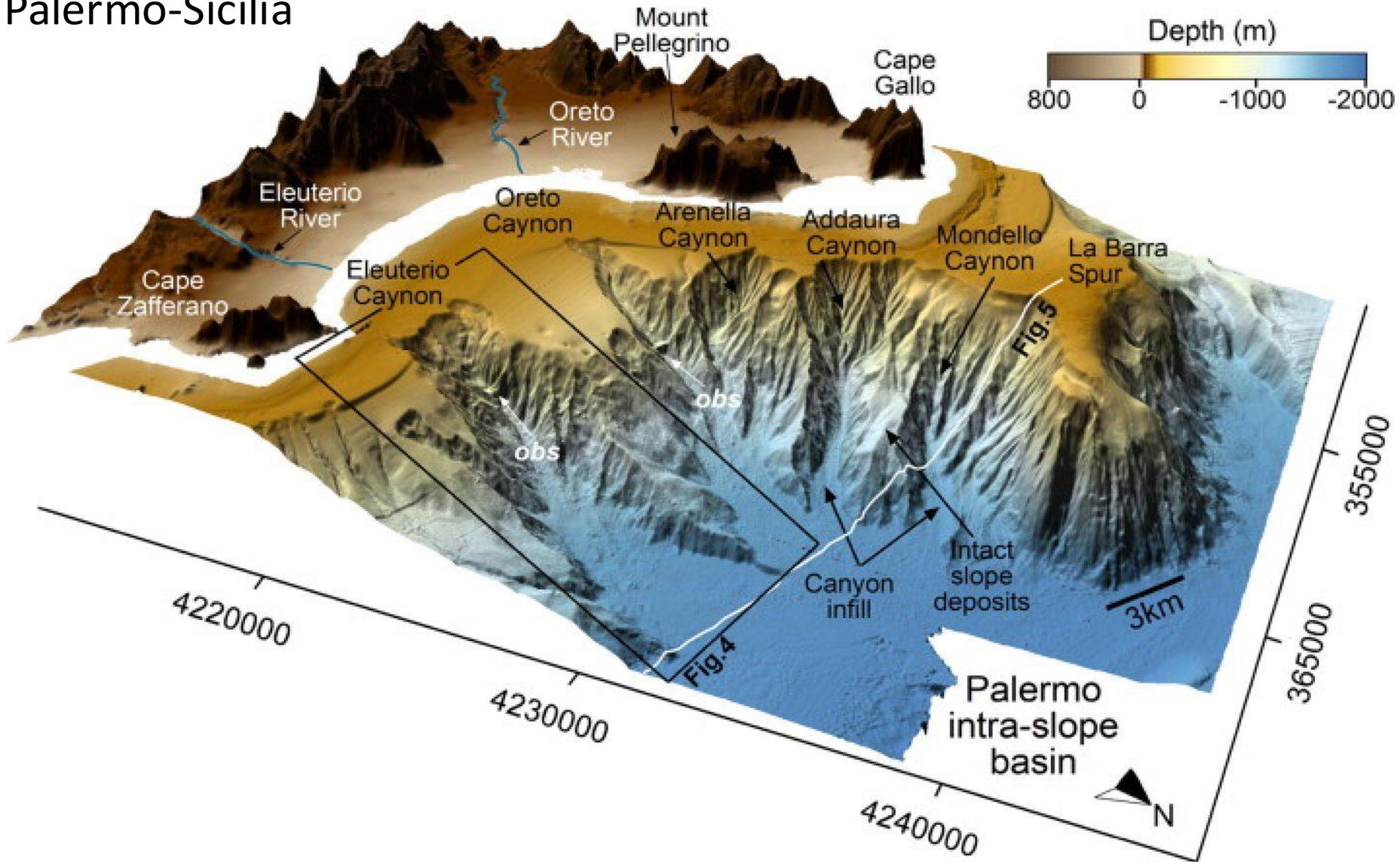
(b) Ter River



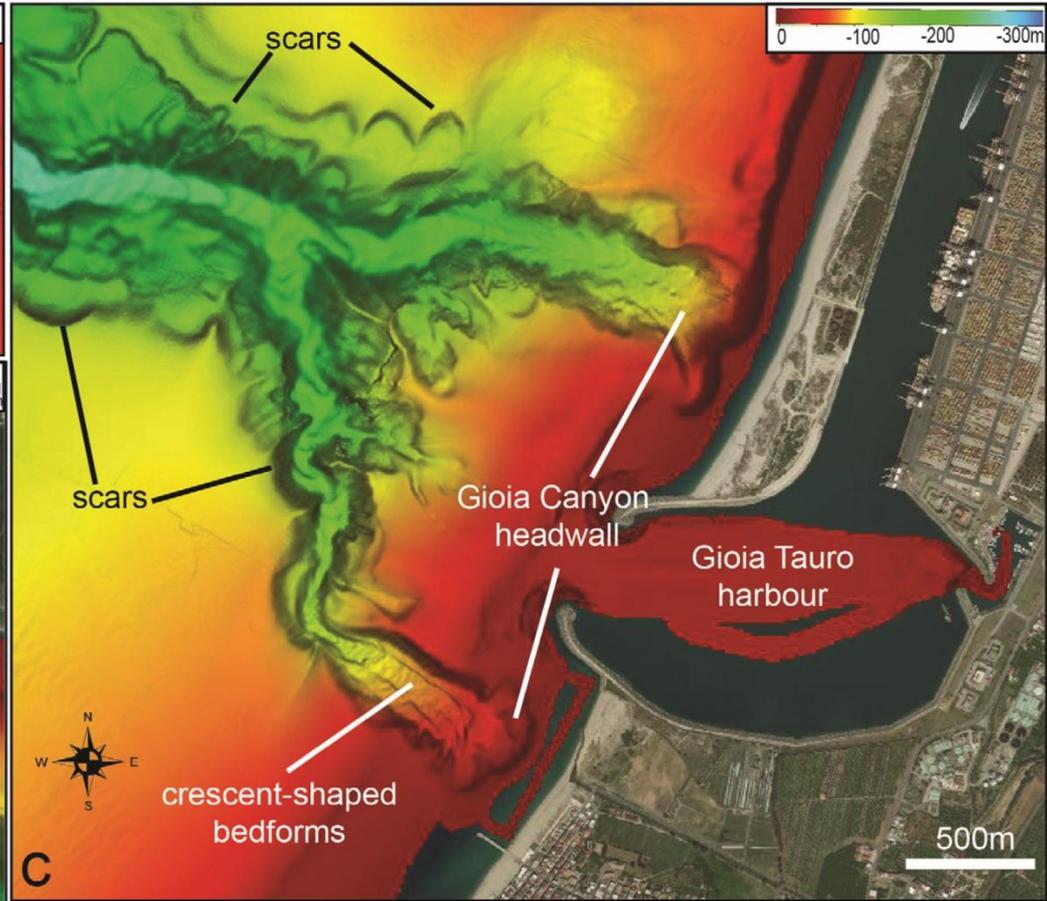
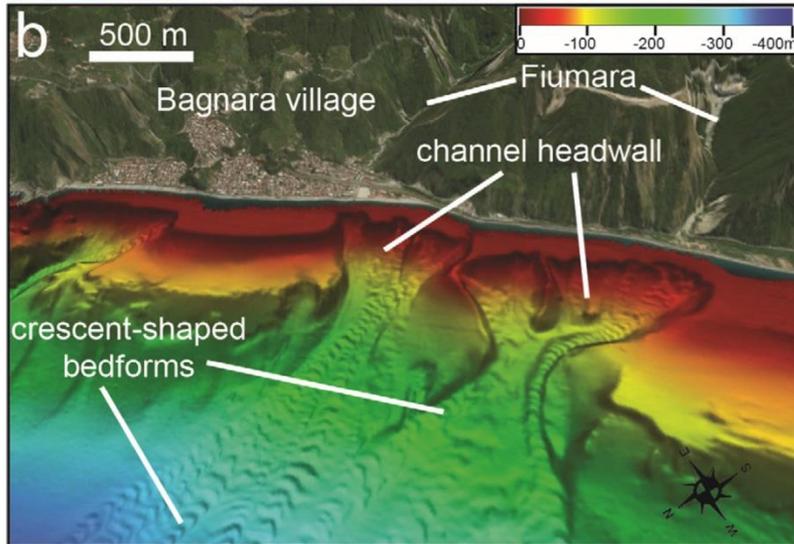
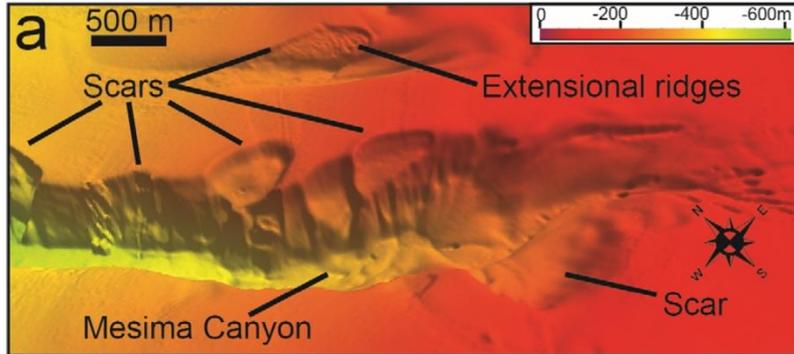
(c) La Fonera Canyon

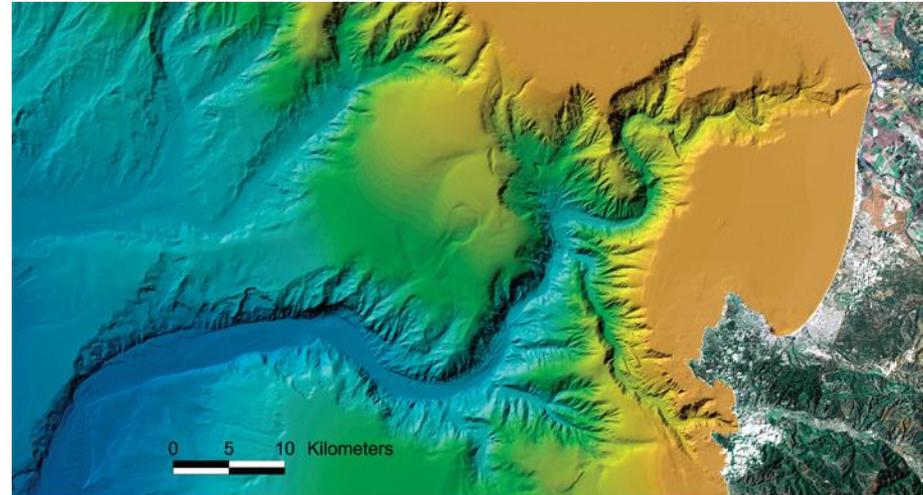
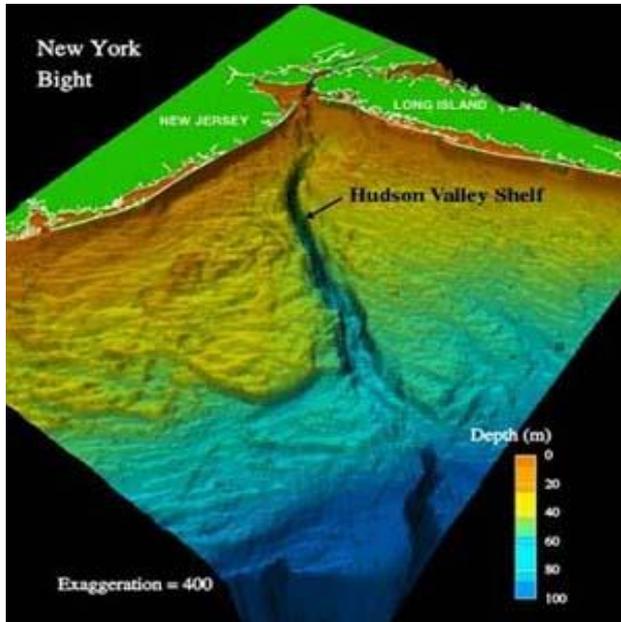


Palermo-Sicilia



Margine Tirreno Calabrese





Hudson Canyon



Monterey Canyon

About 3% of submarine canyons include **shelf valleys** cutting across continental shelves, having upstream ends in alignment with, and sometimes within, the mouths of large rivers, such as the Hudson Canyon.

About 28.5% of submarine canyons **cut** into the continental shelf edge, whereas the majority (**about 68.5%**) have their upstream heading on the continental slope.

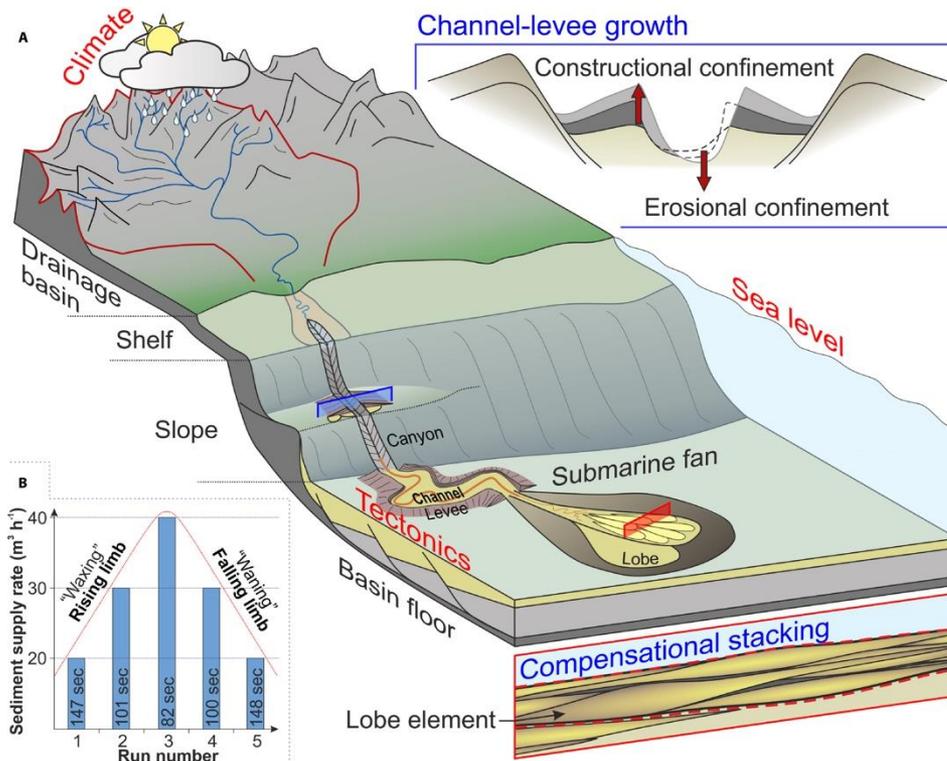
ORIGIN: a) Low-standing sea level (e.g. during LGM or the Messinian Salt Crisis in the Mediterranean *ca.* 5.5 Ma ago)

b) Mass-gravity failure

c) Tectonic initiation

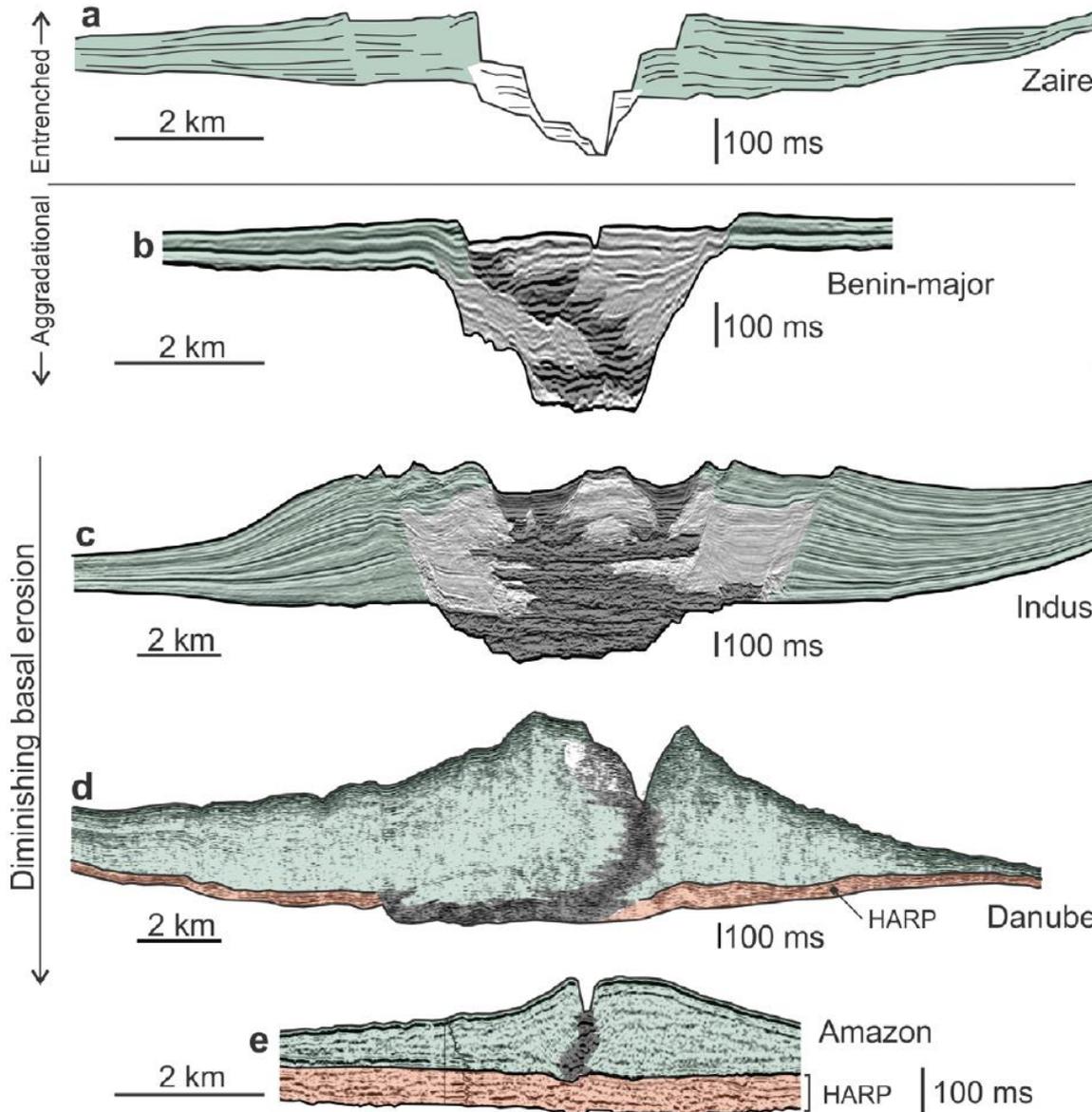
SLOPE SEDIMENTARY CONDUITS ON MID-LATITUDE MARGINS: CANYONS - CHANNELS - GULLIES

Submarine canyons and channels are **conduits** through which **sediments** are **transported across continental margins to deep-sea basins** by sediment gravity flows and other mass movements (Shepard, 1948, 1981; Menard, 1955).



Submarine channels: wide flat valley flanked by depositional channel's levees They originate at the base of continental slopes or on continental rises.

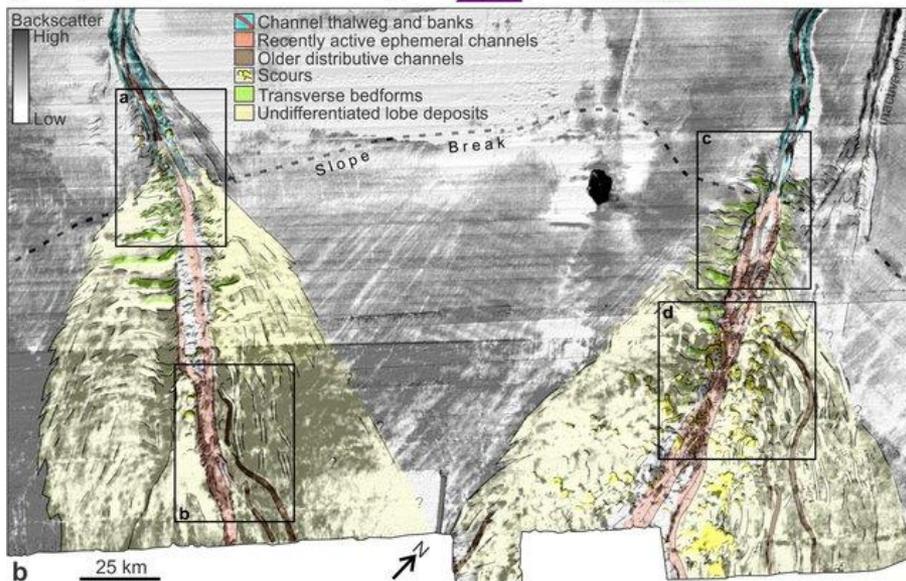
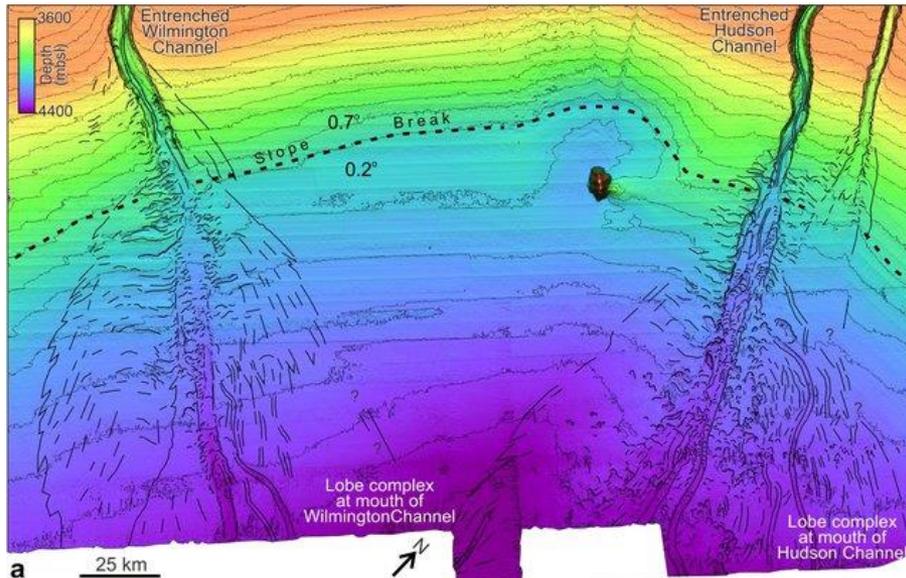
- Initially by-pass, evolve as depositional areas
- U-shaped cross profile flanked by
- Well developed channel's levees (overbank deposits)
- Often sinuous conduit
- 10s-100s km wide
- 10s-1000s km long
- Internal and outer levee sides often hosting slumps/failure



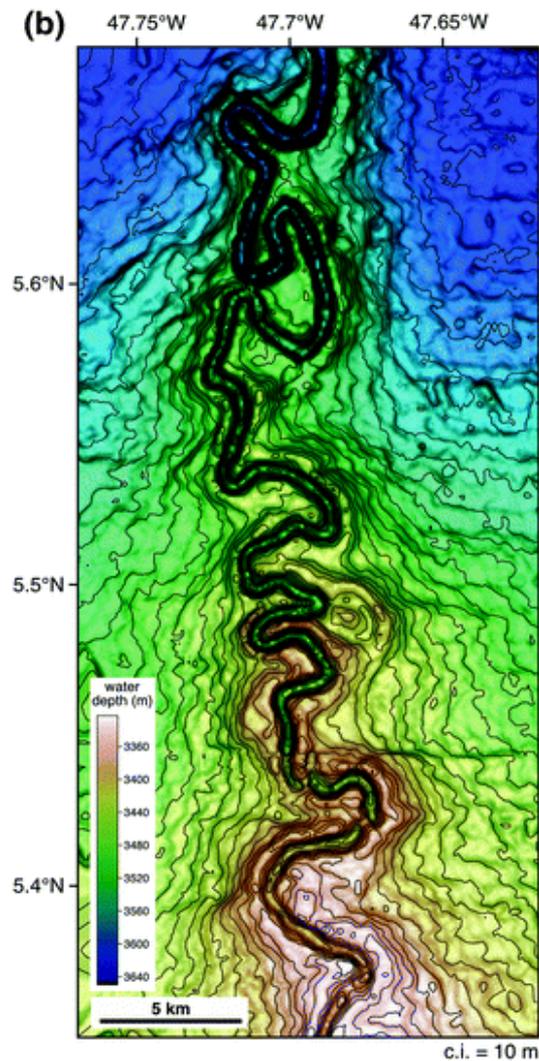
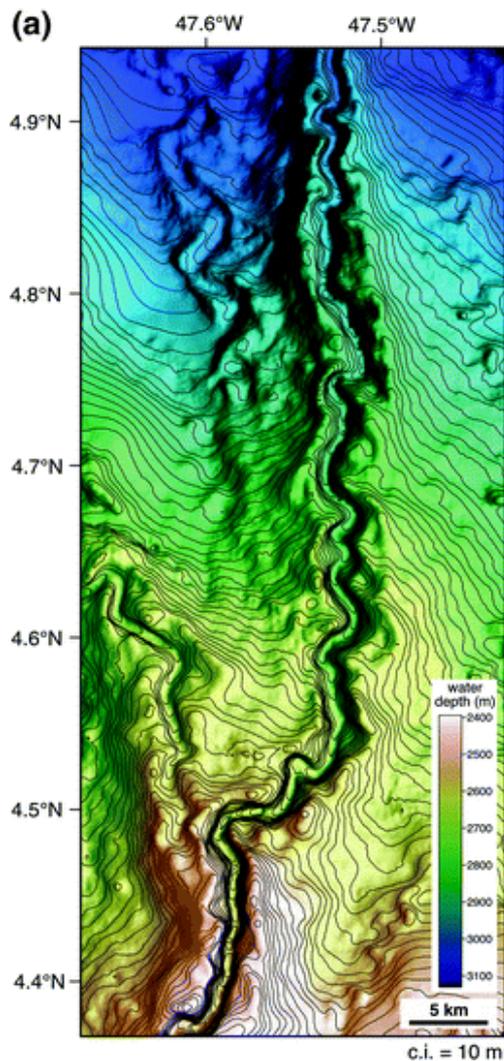
Deptuck & Sylvester, 2018
Submarine Fans and their
channels, levees, and lobes. In:
Submarine Geomorphology,
Springer.

Architectural variations in
long-lived channel-levee
systems (CLS).

- Light grey = Inner levees
- Green = outer levee
- Dark grey = channel
- Orange = avulsion-related lobe deposits

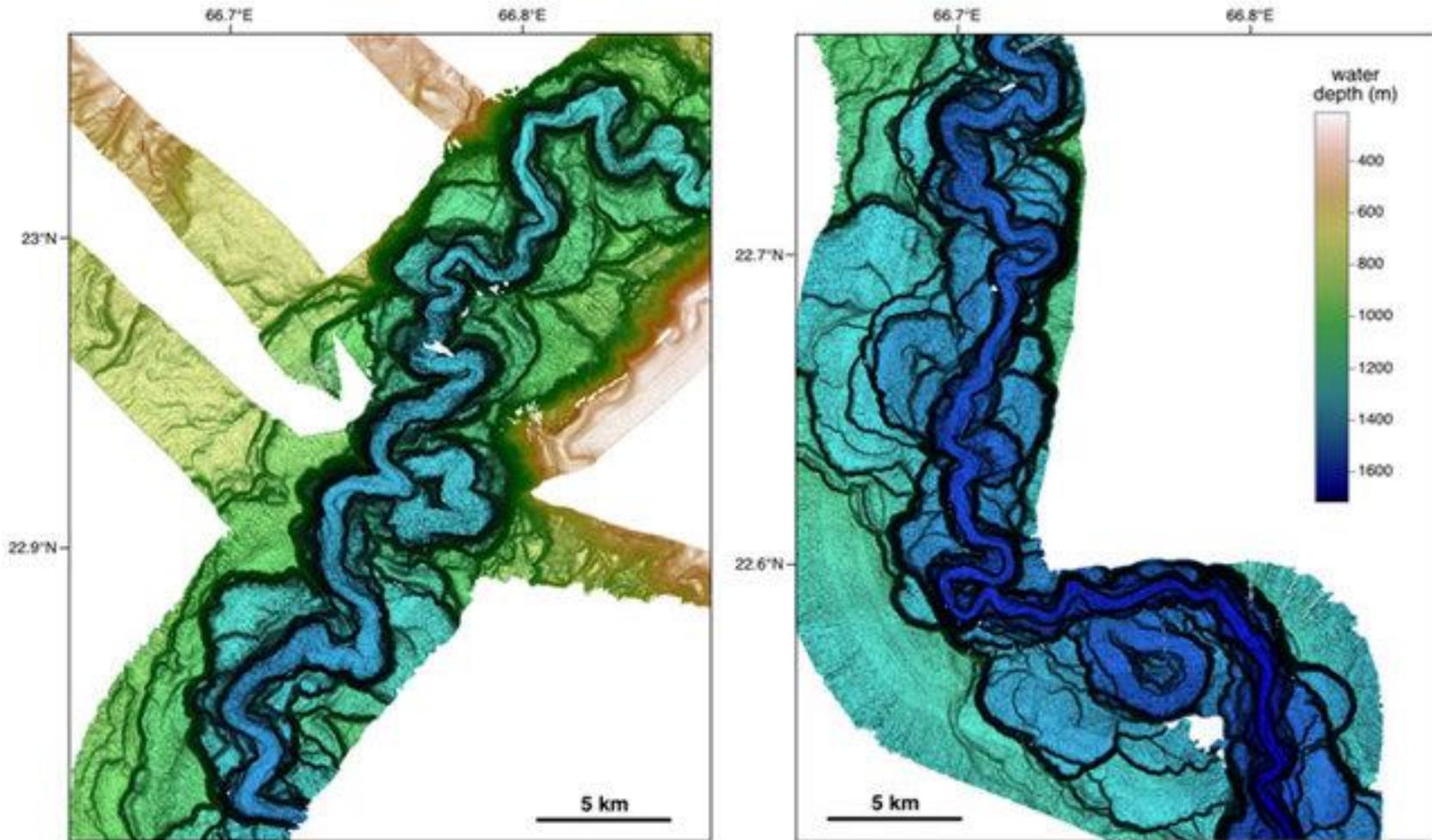


Gardner, 2004: Interpretation of geomorphic features near the channel-lobe transition seaward of Wilmington and Hudson channels. a bathymetry; b backscatter.

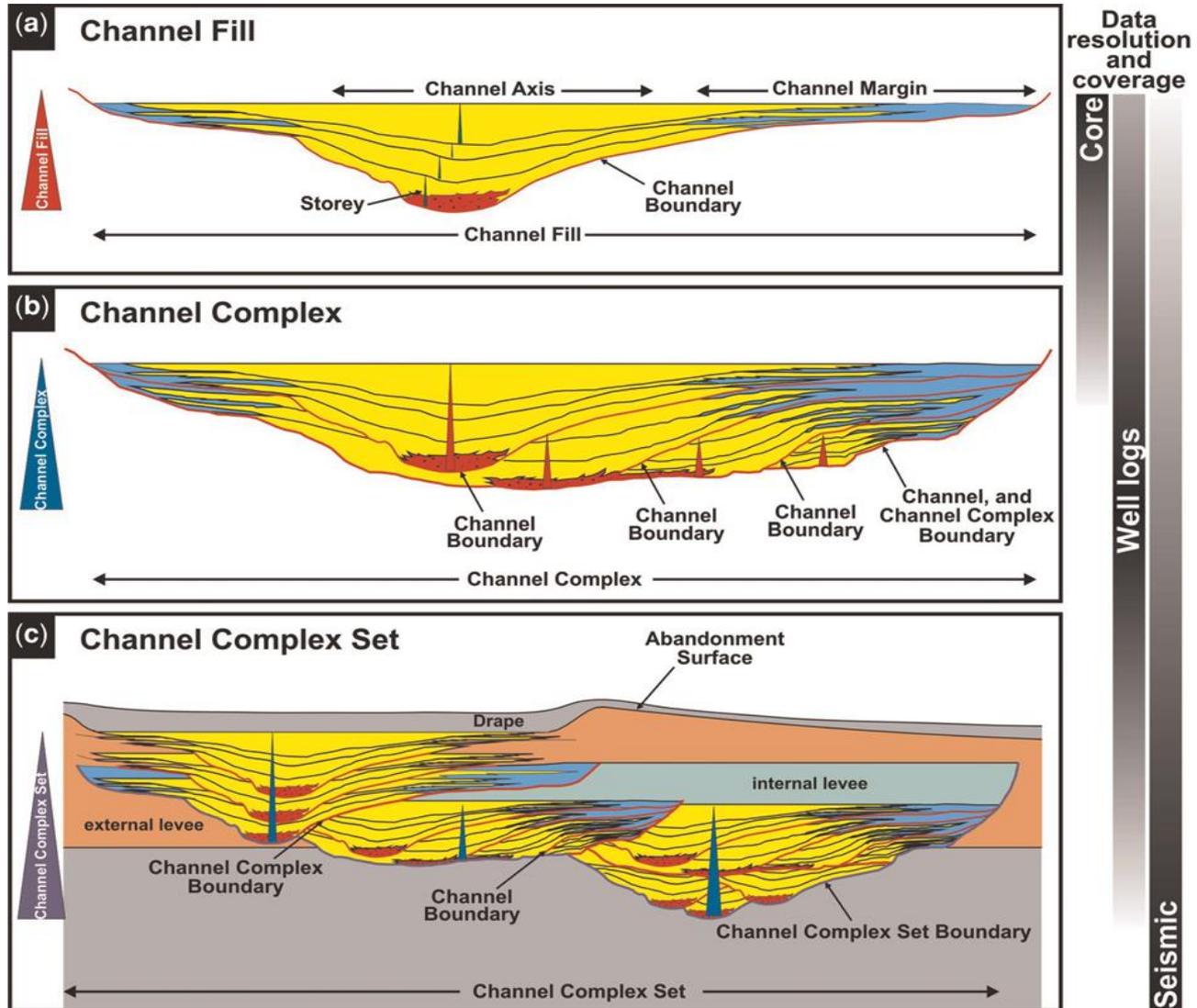


Sinuuous submarine channels
on the **Amazon Fan**.

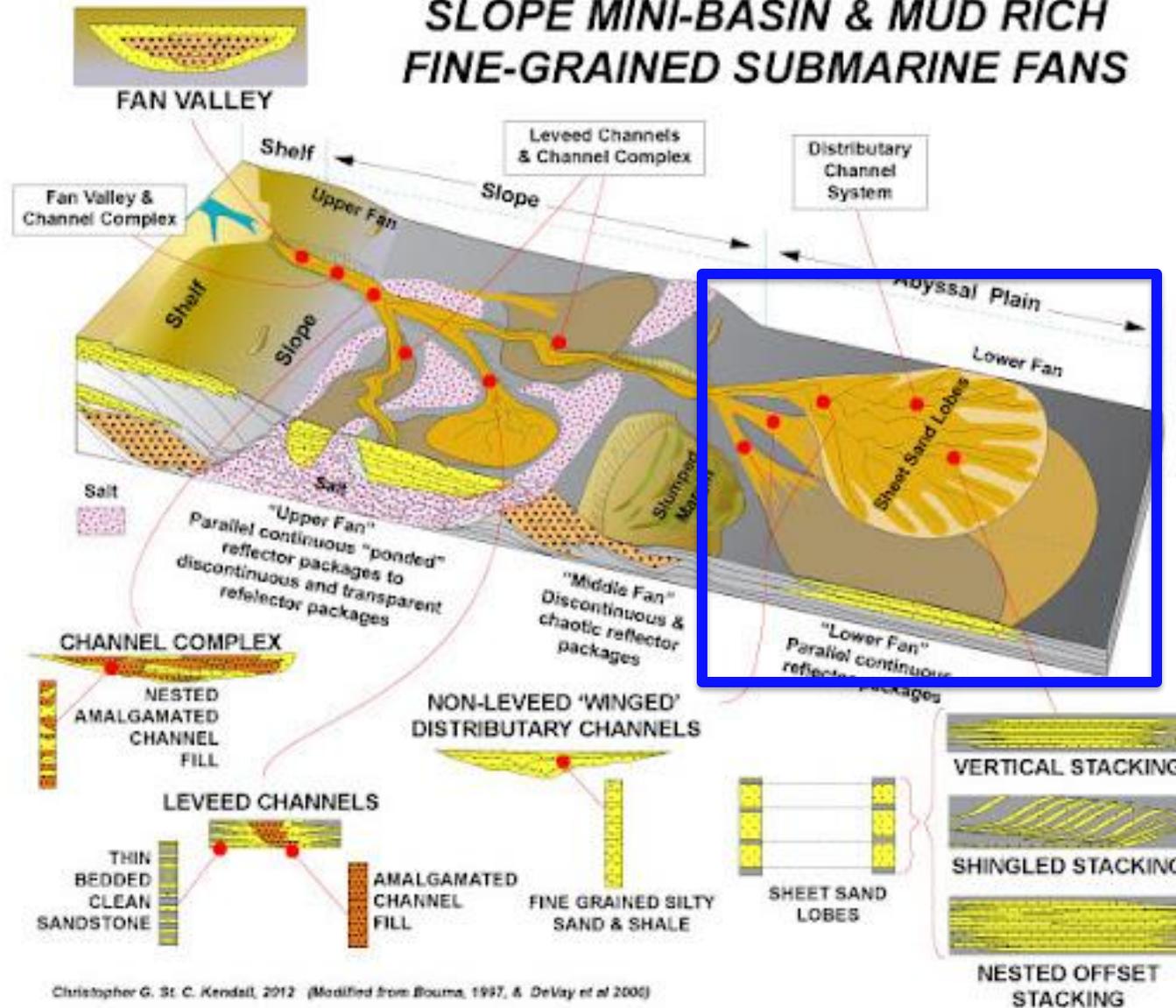
- (a) Avulsion on the upper fan,
 - (b) Higher sinuosity and recent and incipient cutoffs on the middle fan.
- Bathymetry data from NOAA

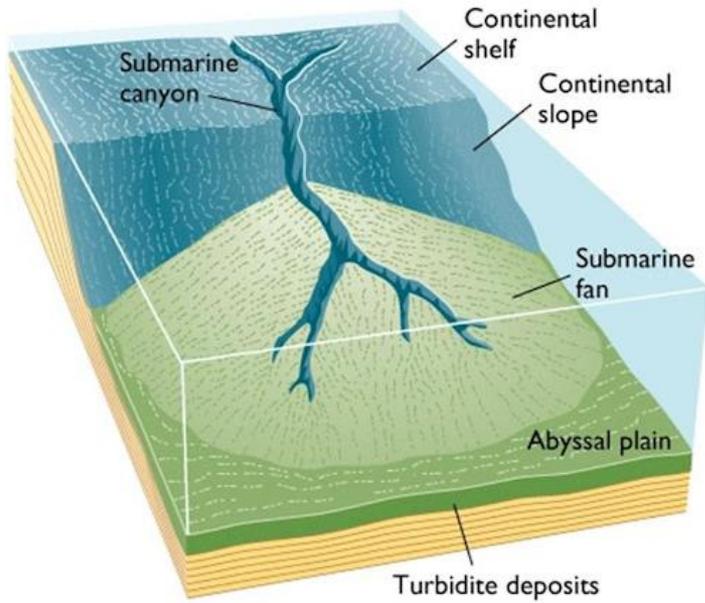


Morphology of large channel-levee systems: the canyon-channel transition zone on the upper part of the **Indus Fan**, with terraces and cutoffs. Data from Clift and Henstock (2015).

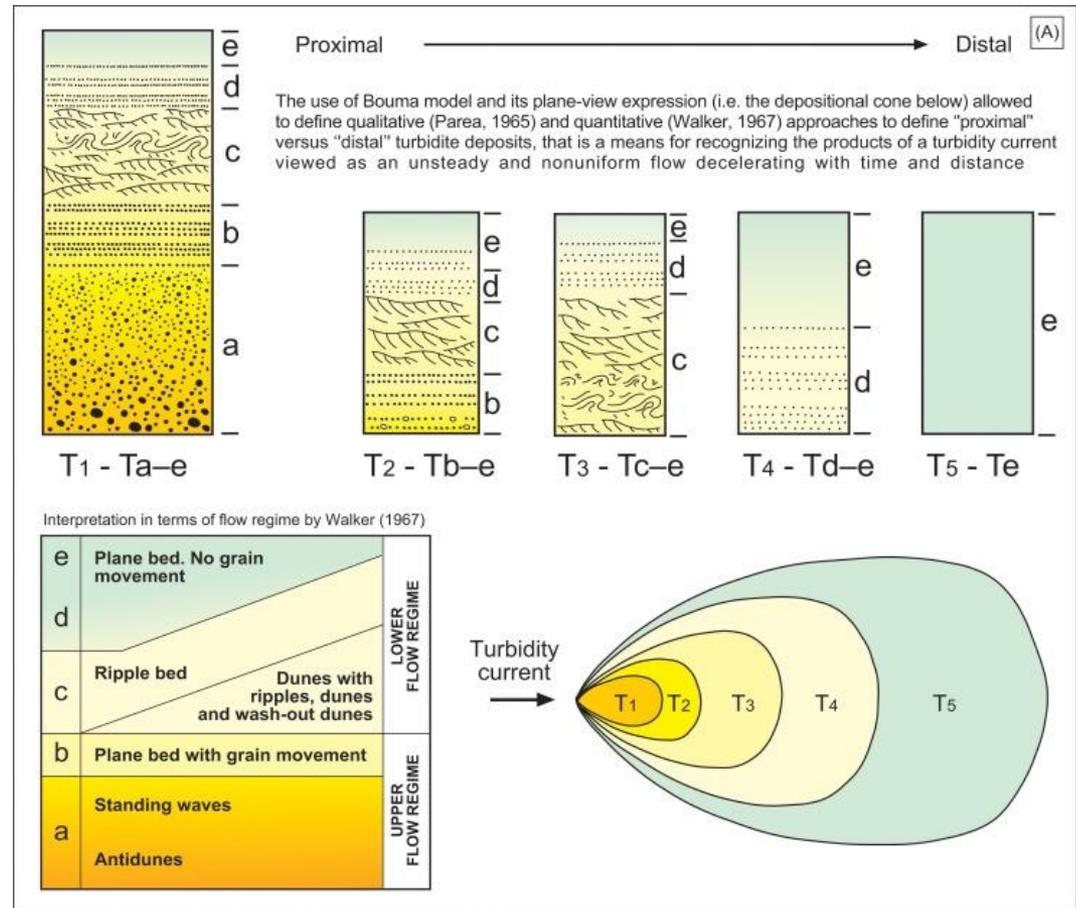


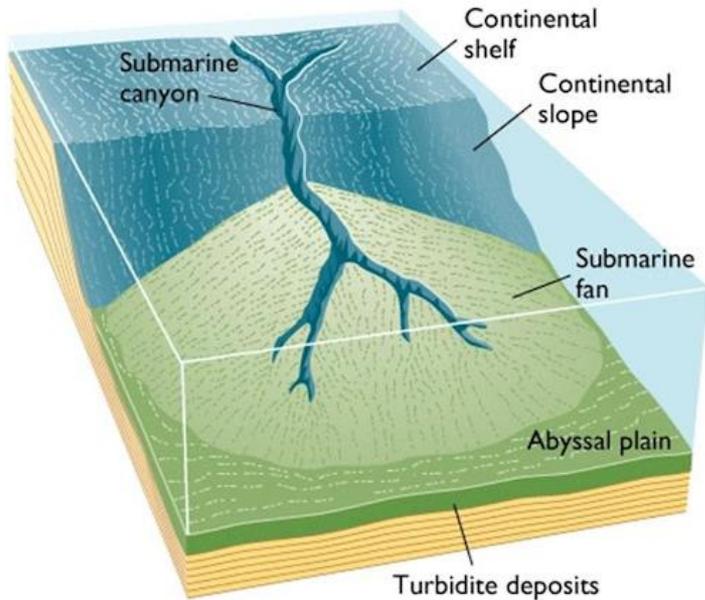
SLOPE MINI-BASIN & MUD RICH FINE-GRAINED SUBMARINE FANS



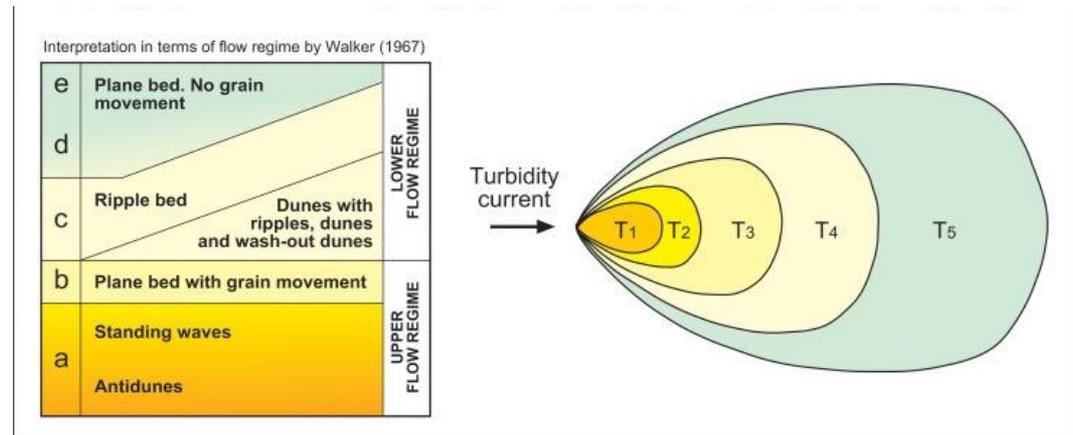
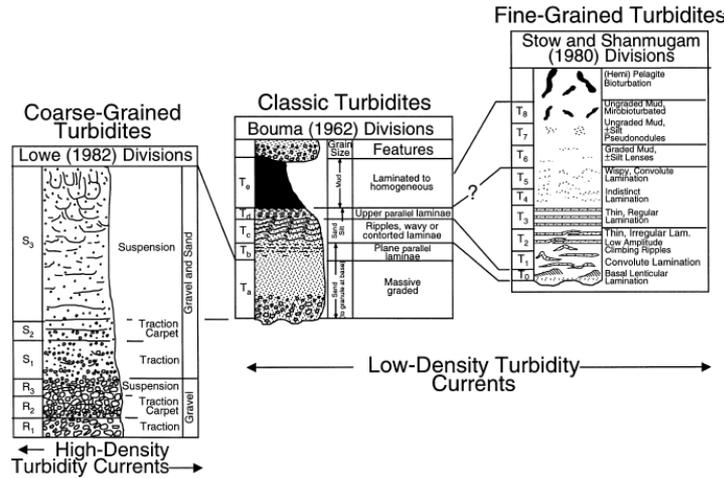
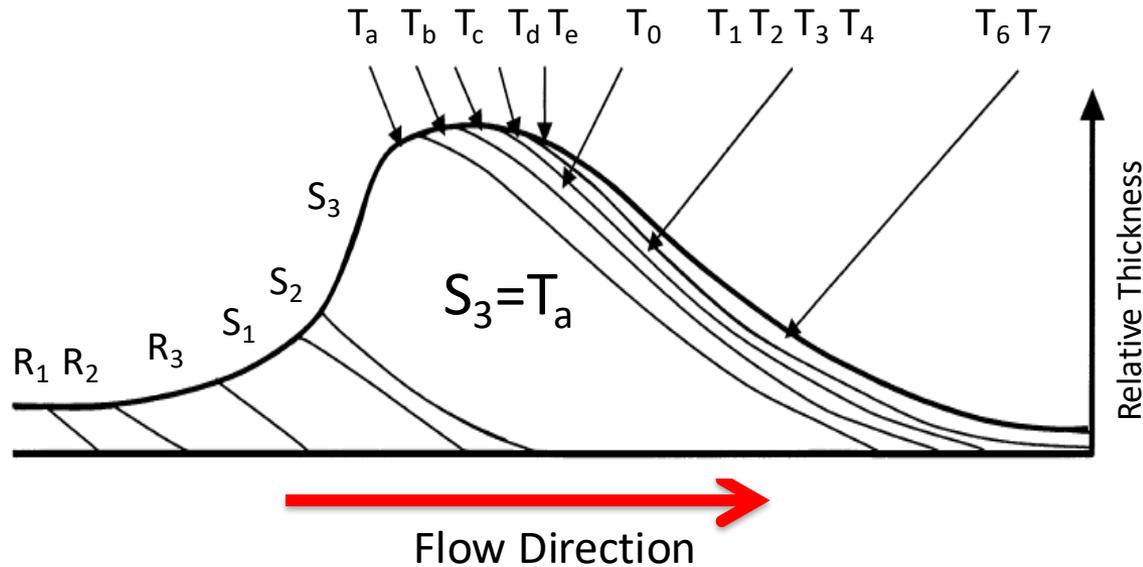


Depositional cone





Depositional cone



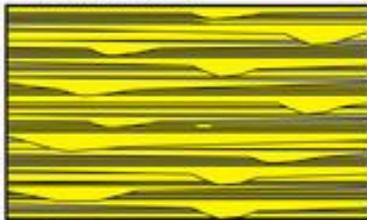
SEDIMENT FACIES in channel-deep sea fan

Ranges are 10th, 50th and 90th quantiles (P_{10} - P_{50} - P_{90}).

SS = Sandstone

MS = Mudstone

Channel Lobe Transition Zone



Bed thickness

SS: 0.10 - 0.31 - 0.78 m

MS: 0.05 - 0.12 - 0.38 m

Thinning Rates

SS: 0.0245 - 0.1653 - 0.9572 cm m^{-1}

MS: 0.0226 - 0.1411 - 0.7902 cm m^{-1}

Correlation Distances

25 - 102 - 526 m

Lobe



Bed thickness

SS: 0.03 - 0.17 - 0.83 m

MS: 0.04 - 0.10 - 0.59 m

Thinning Rates

SS: 0.0125 - 0.1805 - 1.6417 cm m^{-1}

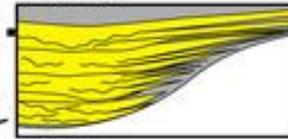
MS: 0.0101 - 0.1029 - 0.7210 cm m^{-1}

Correlation Distances

6 - 30 - 617 m



Channel



Bed thickness

SS: 0.21 - 0.62 - 1.71 m

MS: 0.09 - 0.26 - 1.36 m

Thinning Rates

SS: 0.2090 - 1.610 - 6.0059 cm m^{-1}

MS: 0.0726 - 0.5609 - 3.8278 cm m^{-1}

Correlation Distances

6 - 27 - 112 m

Levee



Bed thickness

SS: 0.09 - 0.18 - 0.27 m

MS: 0.13 - 0.69 - 2.20 m

Thinning Rates

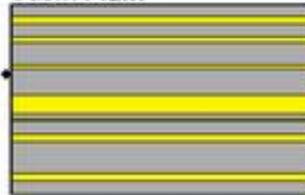
SS: 0.0024 - 0.0192 - 0.0785 cm m^{-1}

MS: 0.0133 - 0.0923 - 0.3192 cm m^{-1}

Correlation Distances

223 - 490 - 1084 m

Basin Plain



Bed thickness

SS: 0.09 - 0.41 - 1.01 m

MS: 0.39 - 0.97 - 2.26 m

Thinning Rates

SS: .000017 - 0.0012 - 0.0054 cm m^{-1}

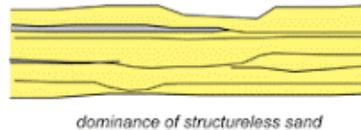
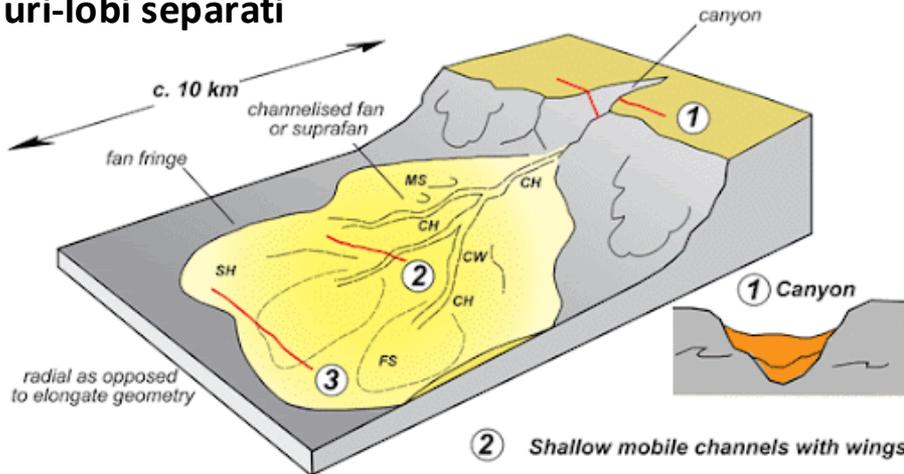
MS: .000033 - 0.0017 - 0.0073 cm m^{-1}

Correlation Distances

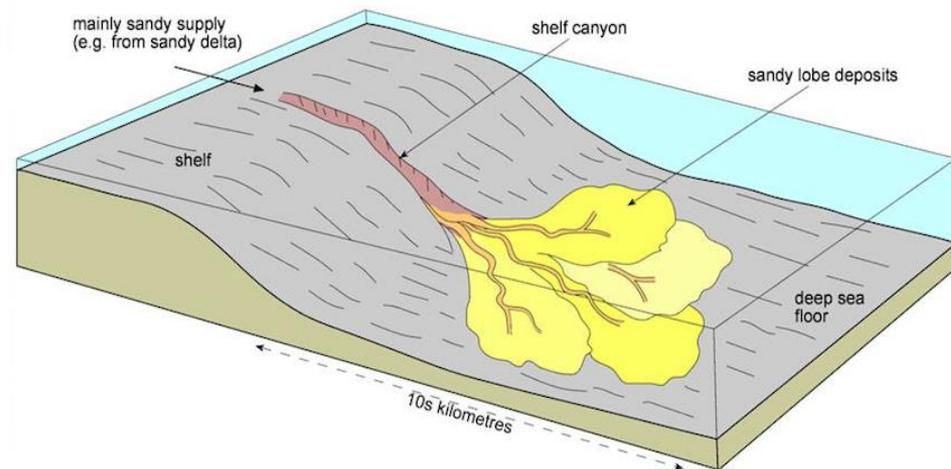
3394 - 11 866 - 32 987 m

NUMBER and LOCATION of lobes forming deep sea fans

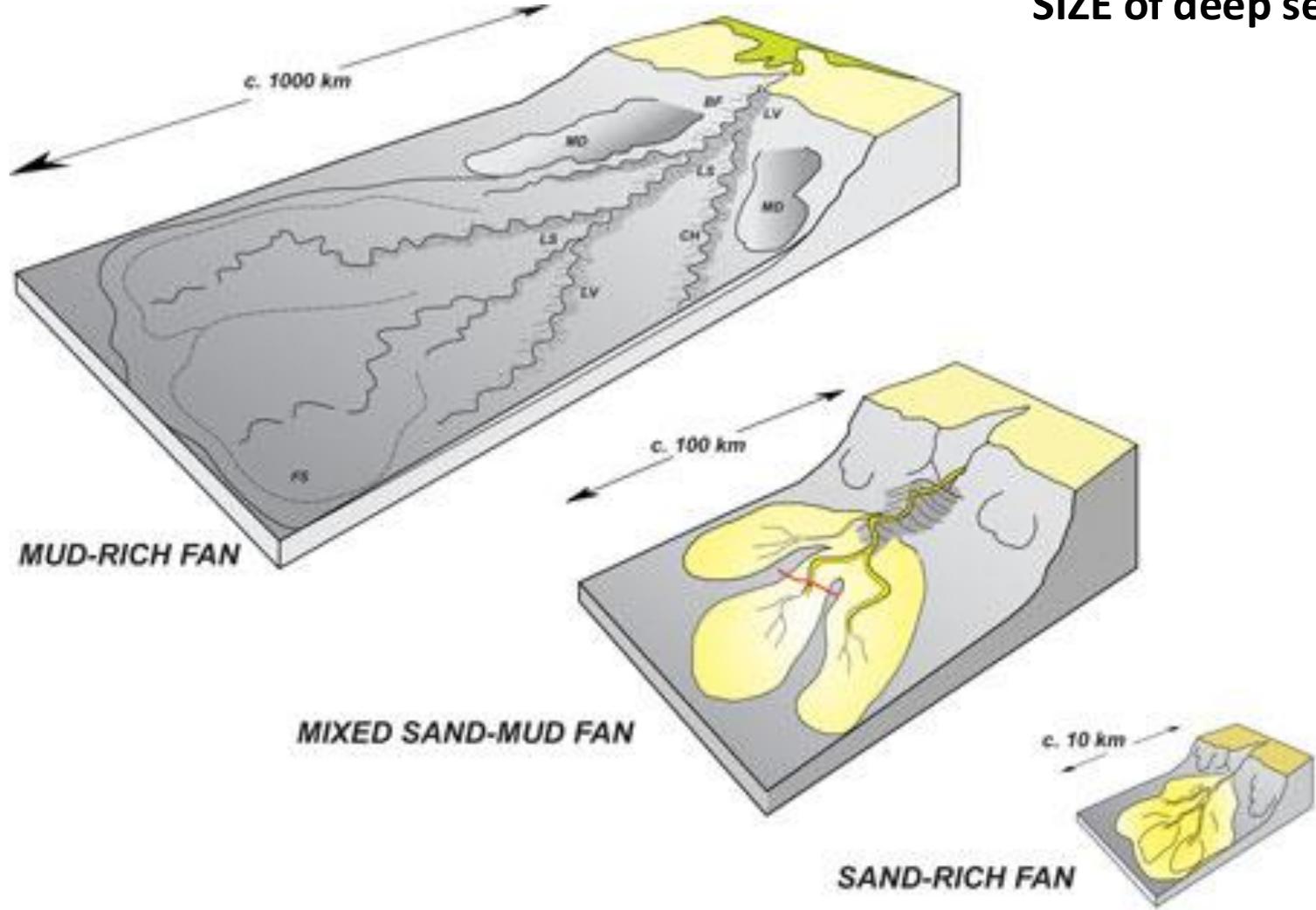
Pluri-lobi separati

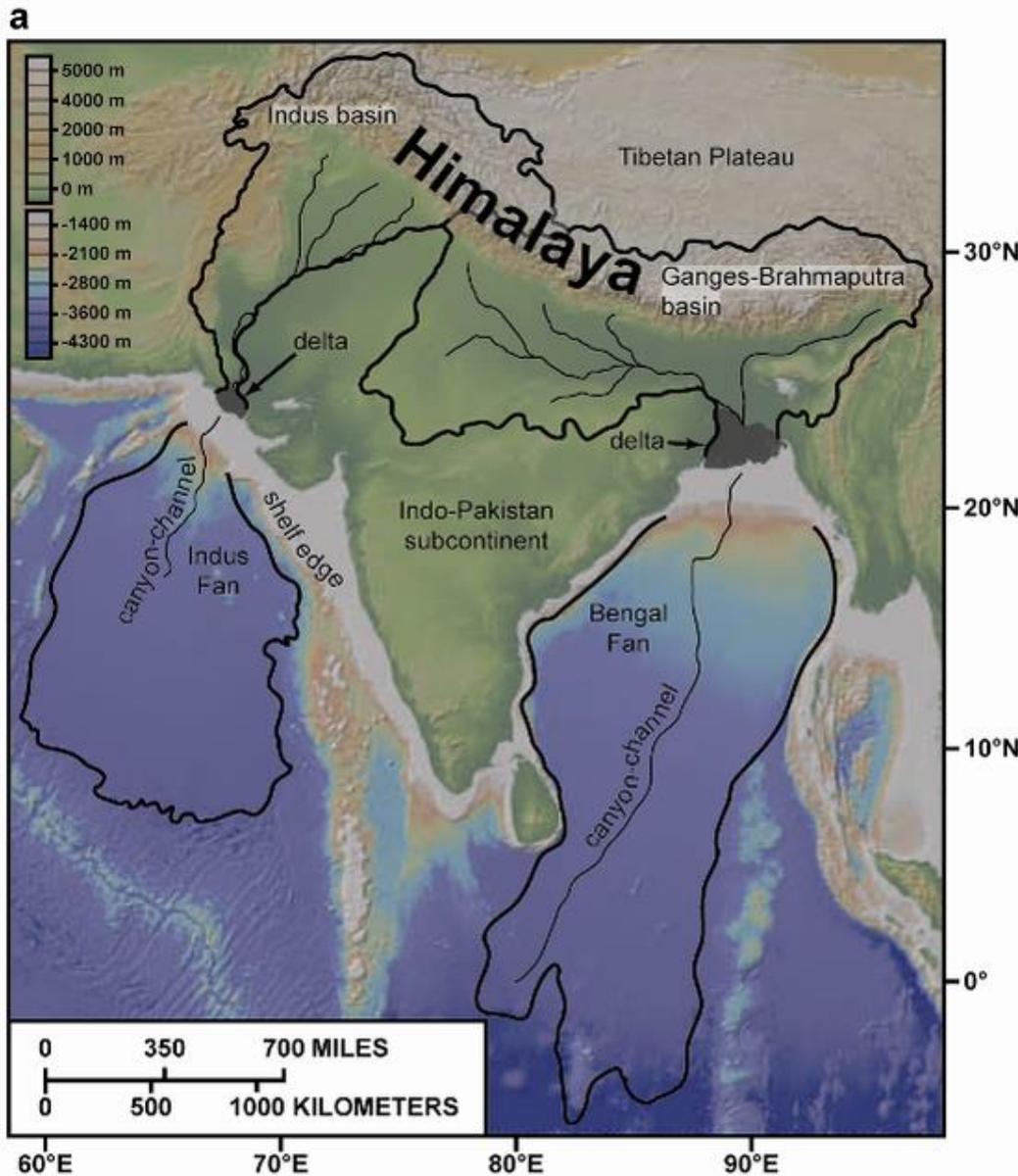


Pluri-lobi coalescenti



SIZE of deep sea fans

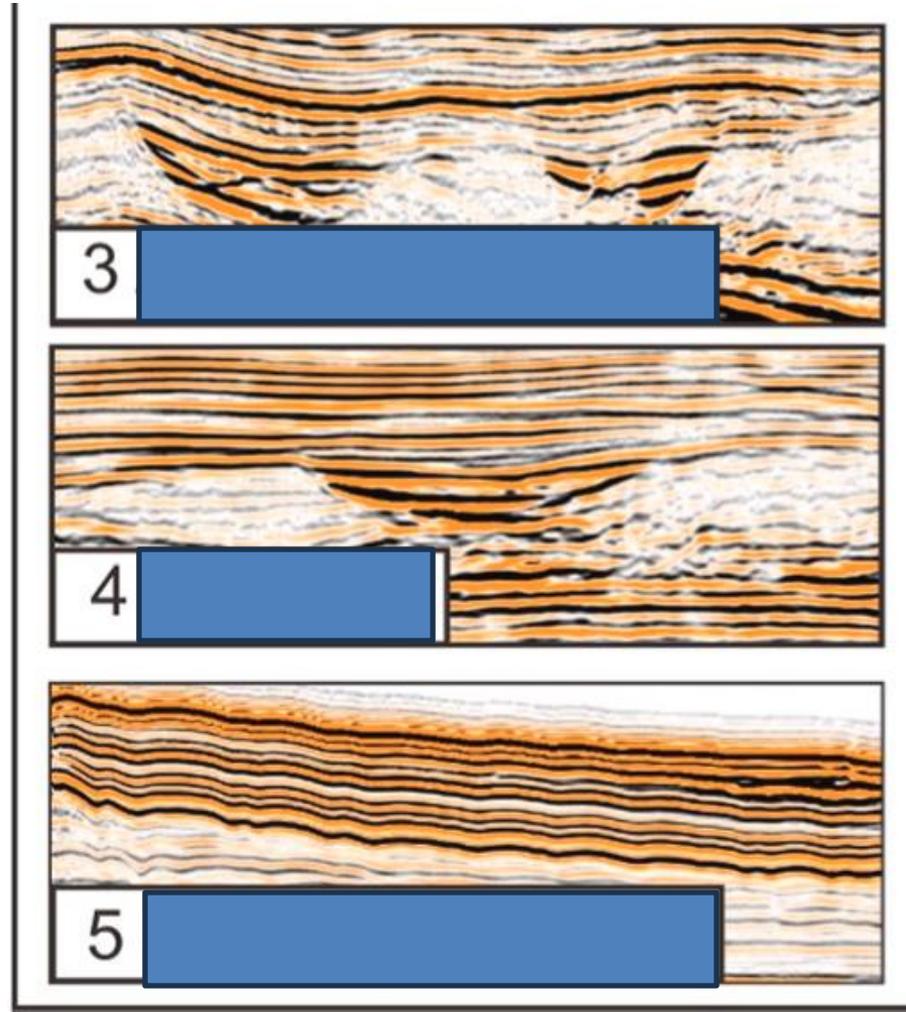
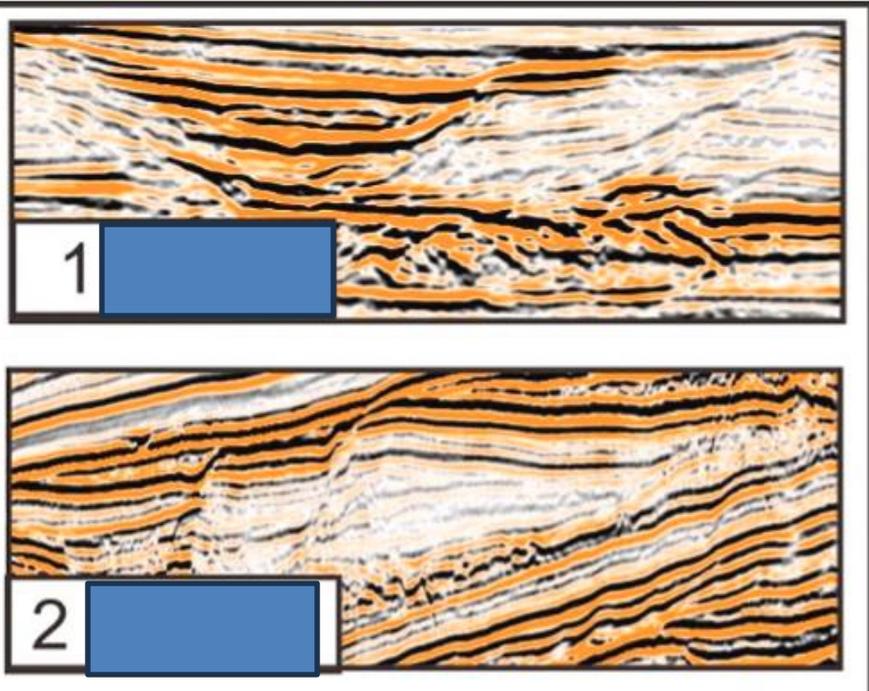




SIZE of deep sea fans

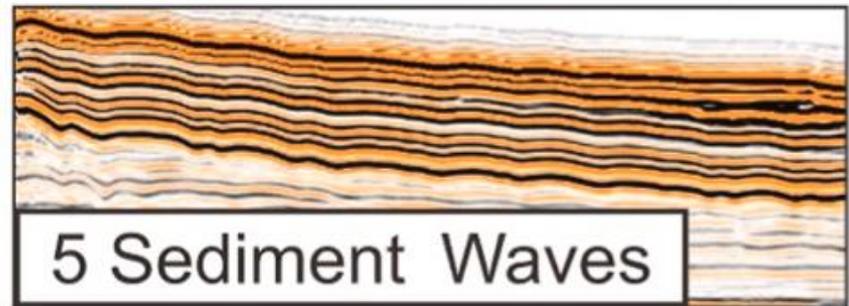
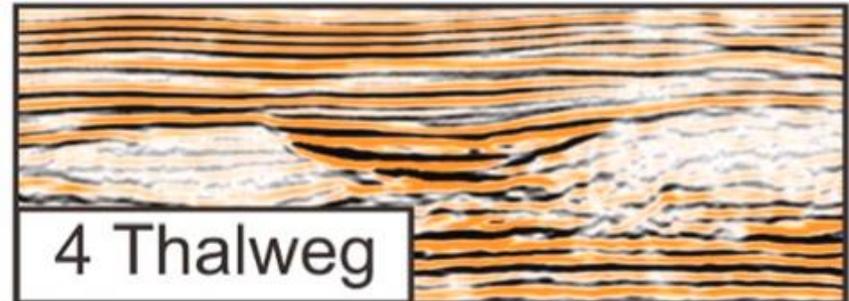
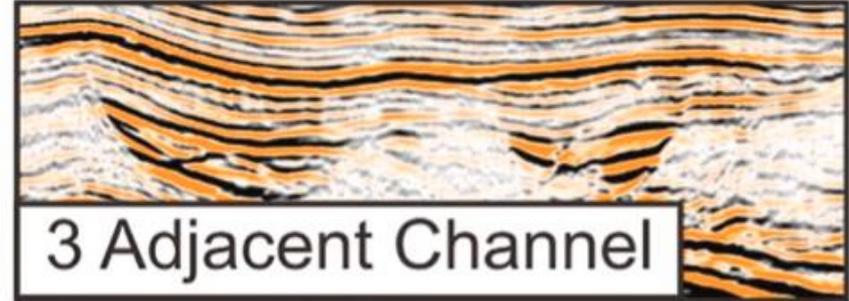
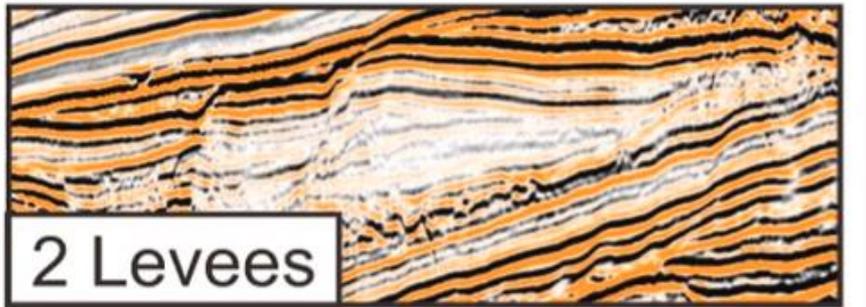
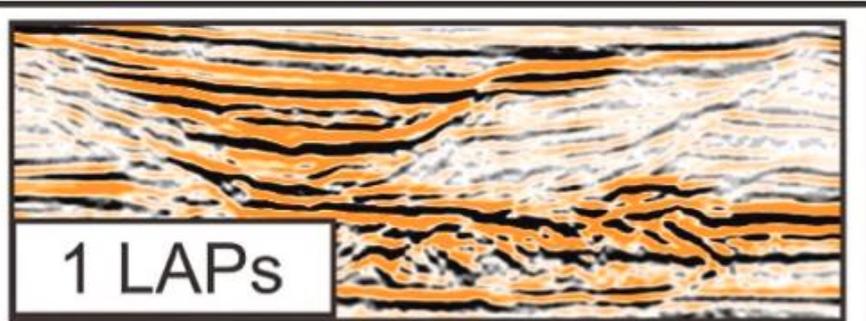
Architectural complexities and morphological variations of the
indus fan and its elements: Understanding of the turbidite
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Haq et al, 2023, Marine and Petroleum Geology



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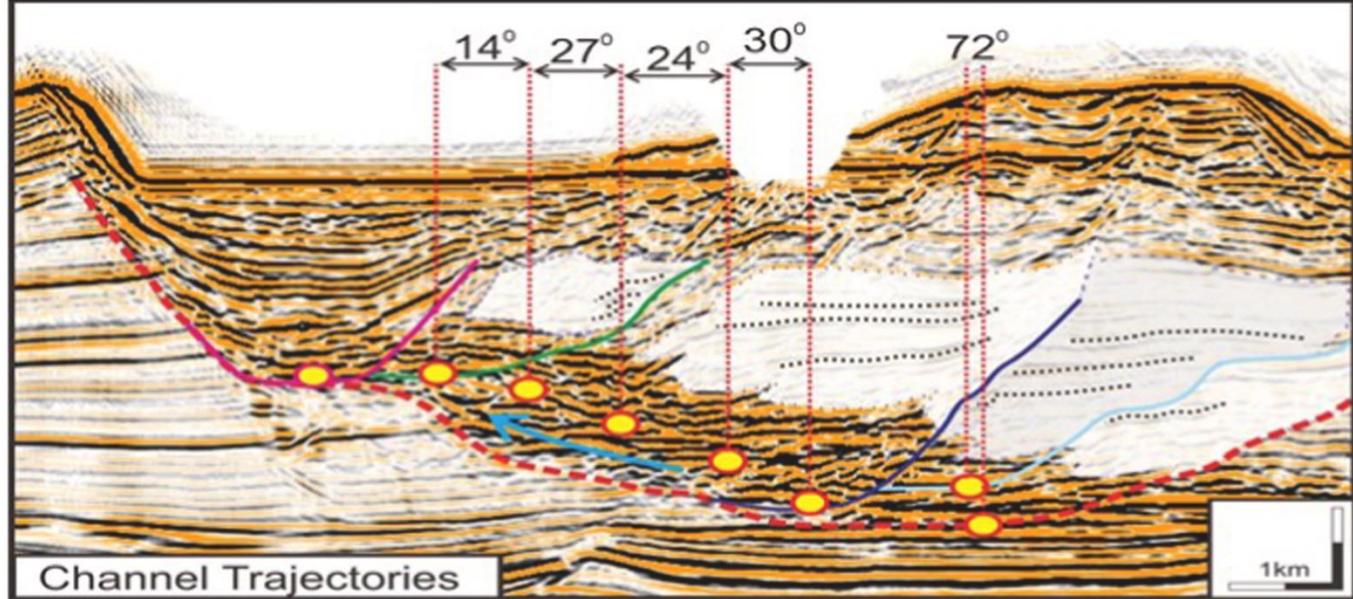
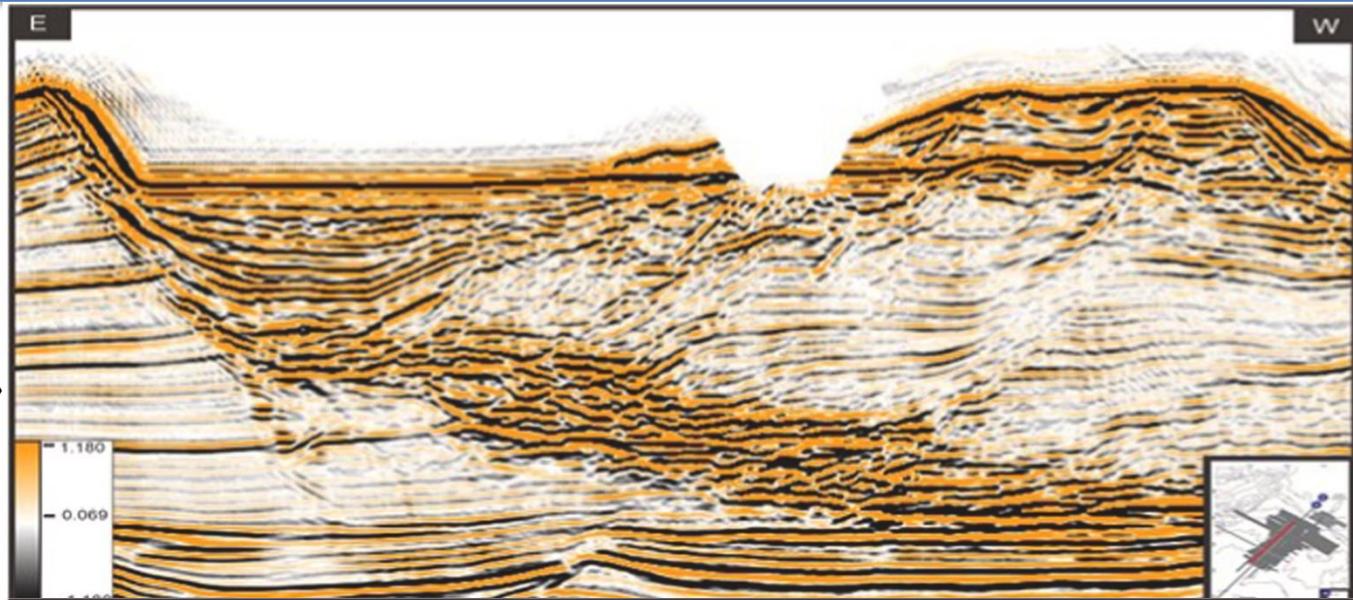
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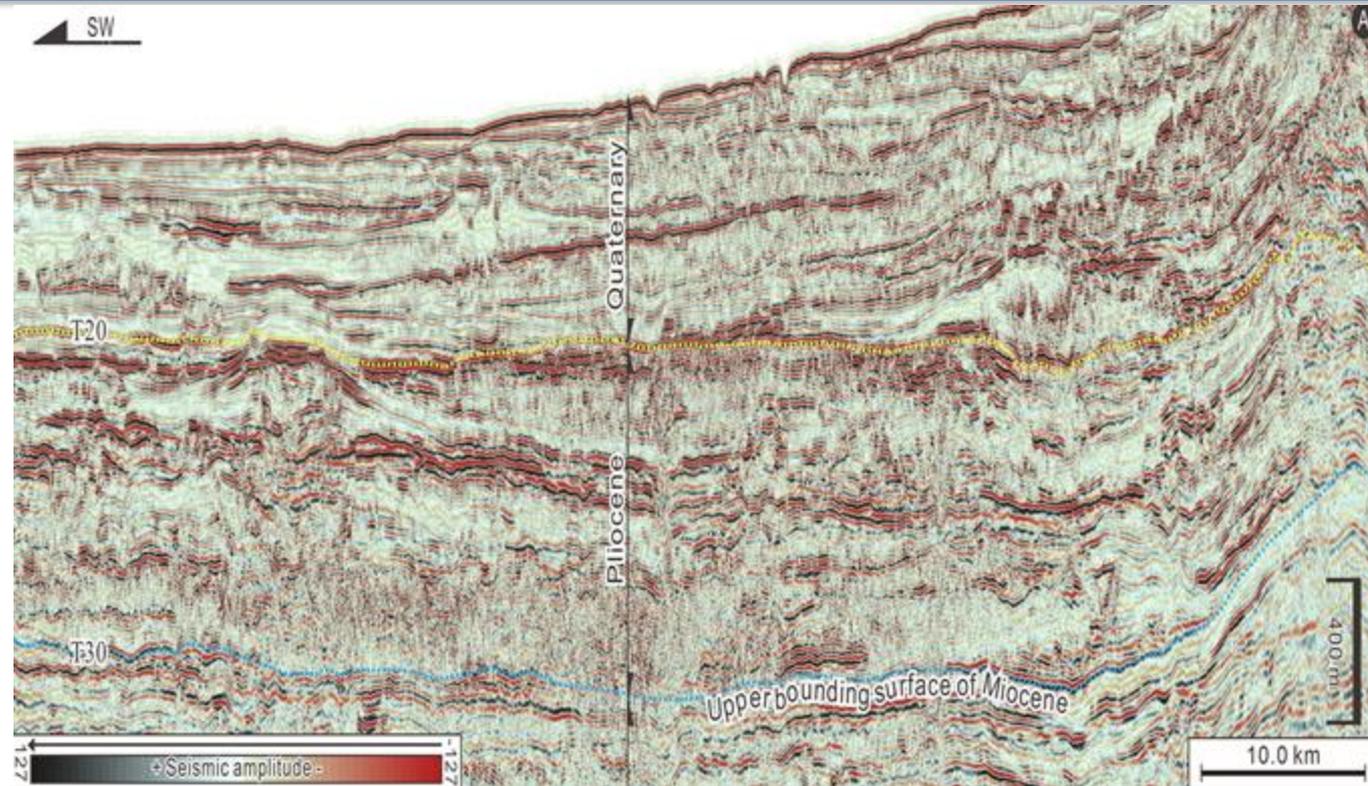
Exercise:
Trace the channel(s)!

Quantify how it is «moving»

Seismic profile with unidirectionally migrating channel. Higher angles of channel growth suggest aggradation and smaller angles indicate lateral migration. The red dotted line represents the basal erosive surface; yellow circles represent the channel fill trajectory.



Can you find them?



Morphological and architectural evolution of submarine channels: An example from the world's largest submarine fan in the Bay of Bengal

Dongwei et al, 2023,

Marine and Petroleum Geology

