Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Università degli studi di Trieste

LAUREA MAGISTRALE IN GEOSCIENZE

Classe Scienze e Tecnologie Geologiche

Curriculum: Esplorazione Geologica

Anno accademico 2024 - 2025

Analisi di Bacino e Stratigrafia Sequenziale (426SM)

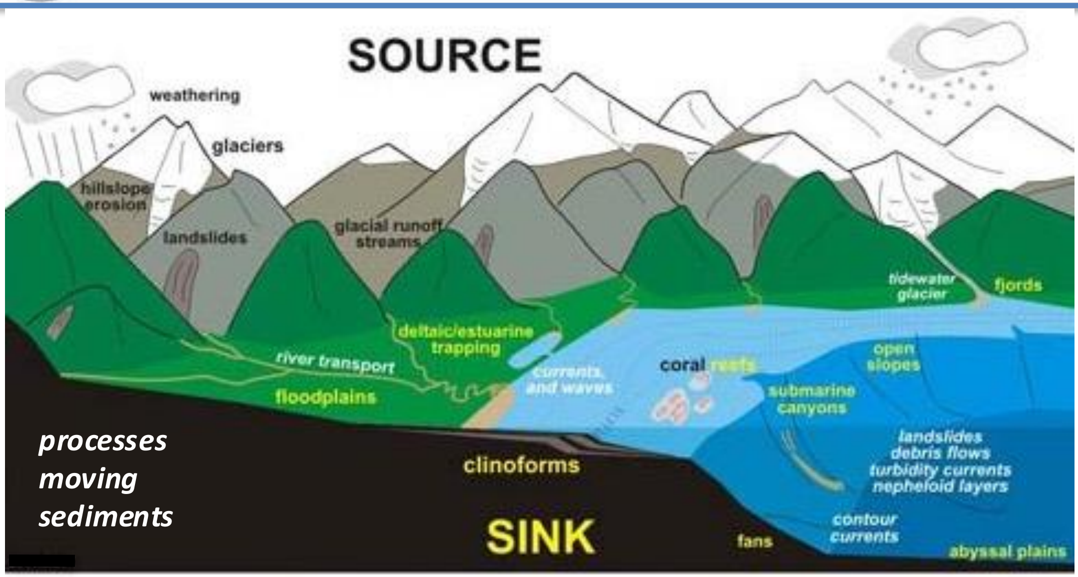
Docente: **Michele Rebesco**

Unit 3.4
Continental Slope: Sediementary structures associated to gravit flows

Teacher: **Renata G. Lucchi**

OUTLINE

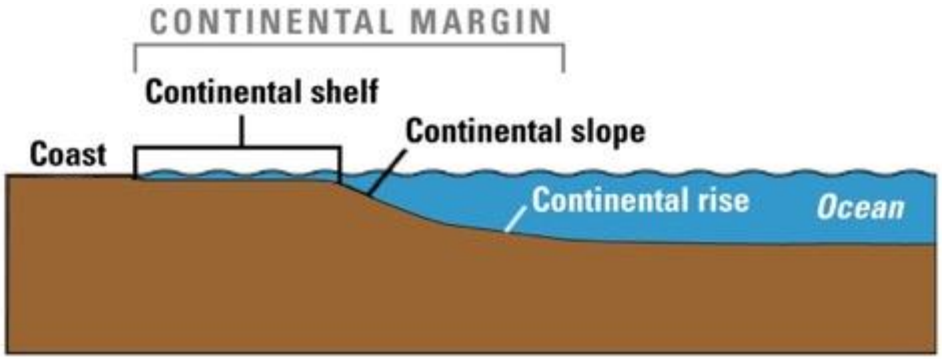
- The source to sink system
- Continental slope types and key features
- Continental slopes at high latitude margins (TMFs, gullies, channels)
- Continental slopes at mid latitude margins (canyon-channel-deep sea fans systems)
- Identifying submarine landslides and debris flows



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)

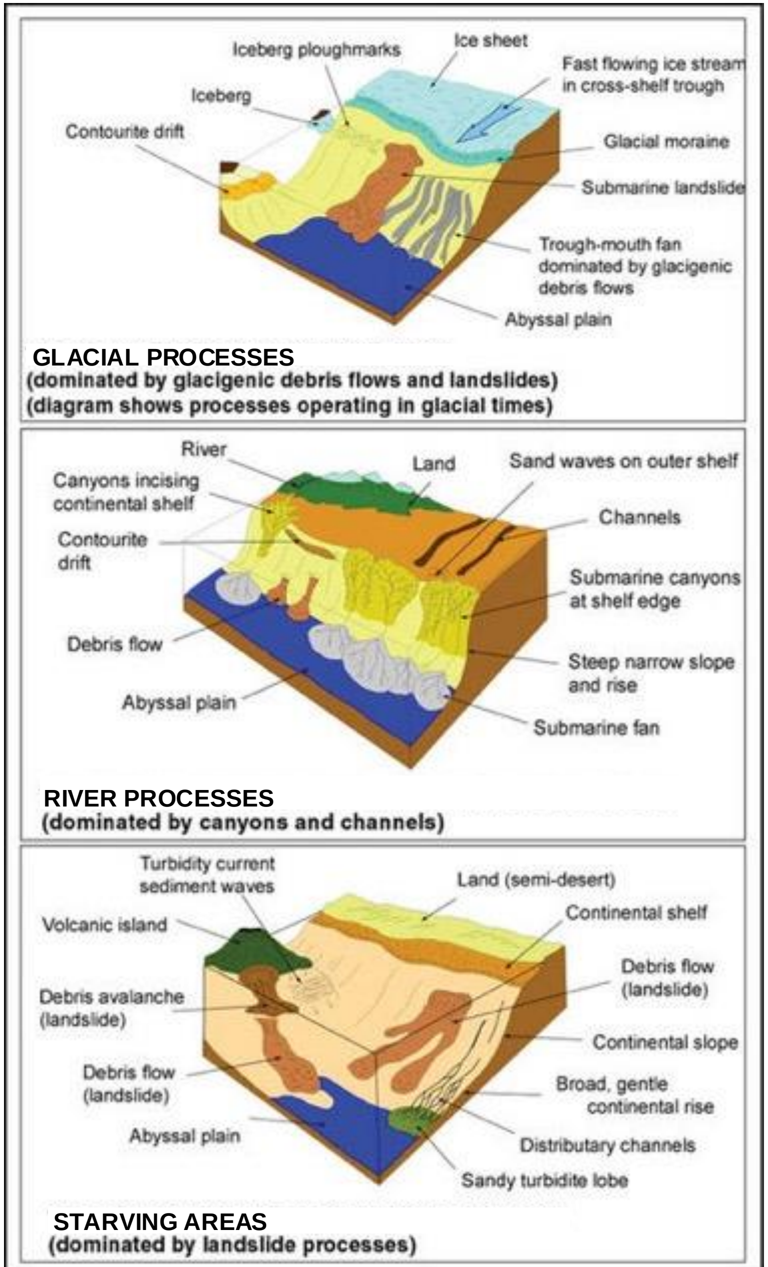


Continental shelf
Preferential area of sediment accumulation
High sediment accumulation
High isostatic subsidence
Continental slope sediment deposition and transfer toward deeper environments
Continental rise: sediment deposition (deep sea fans, sediment drifts)

High latitude

Mid latitude

Low latitude



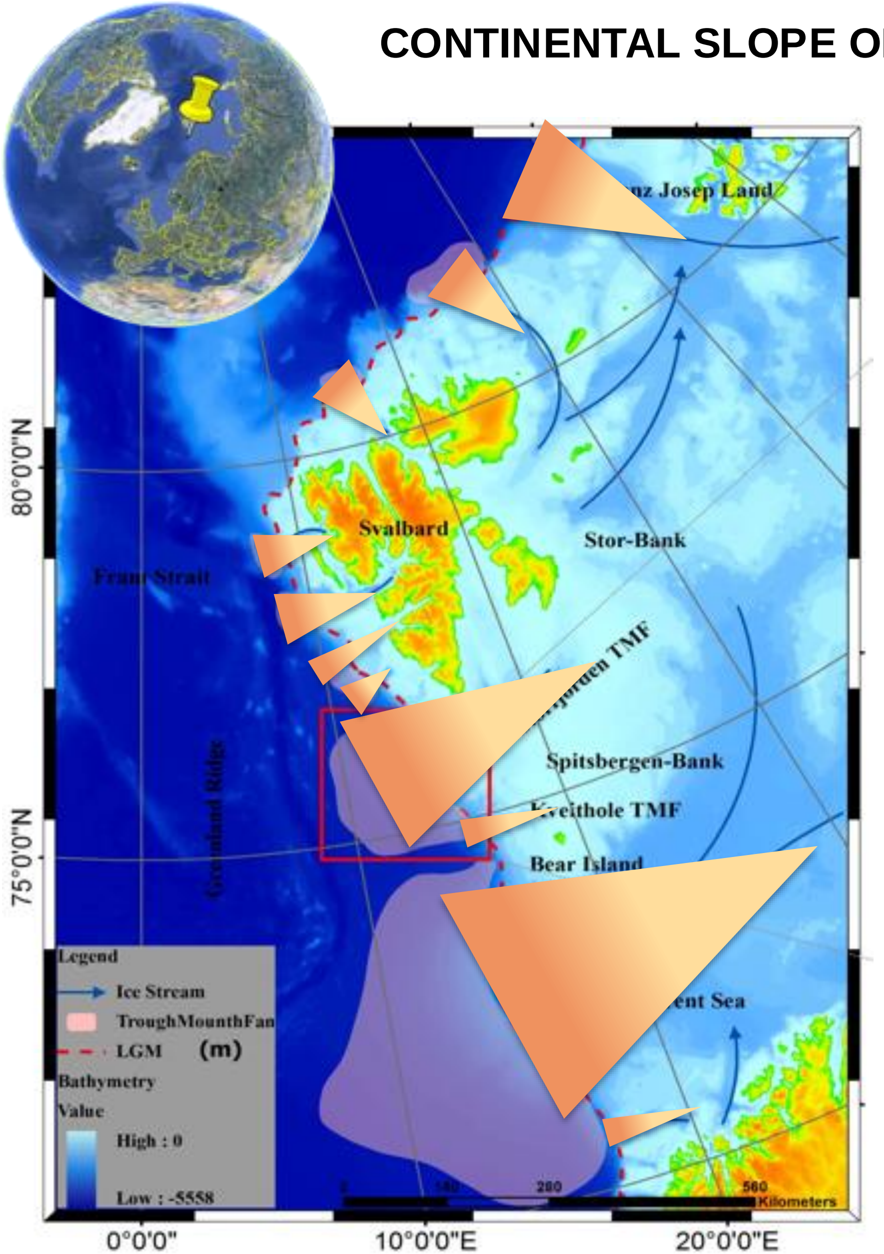
Continental slope types and related distinctive sedimentary features

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

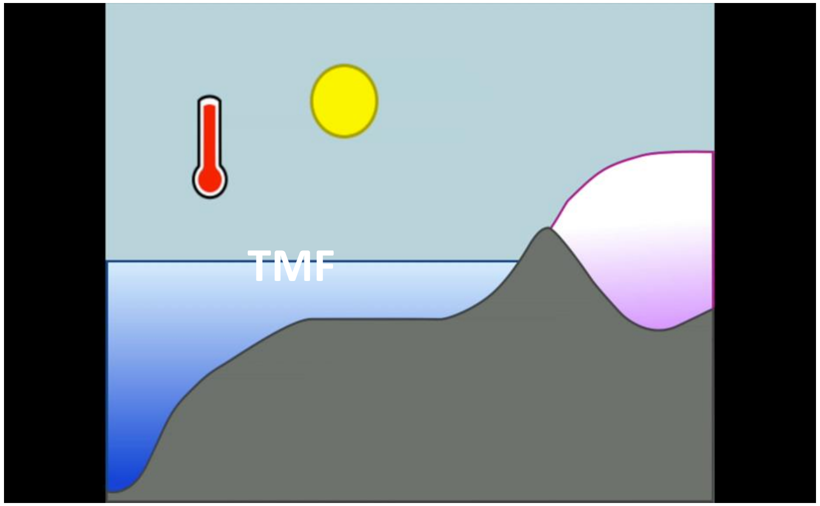
CONTINENTAL SLOPE ON GLACIATED GLACIATED MARGINS

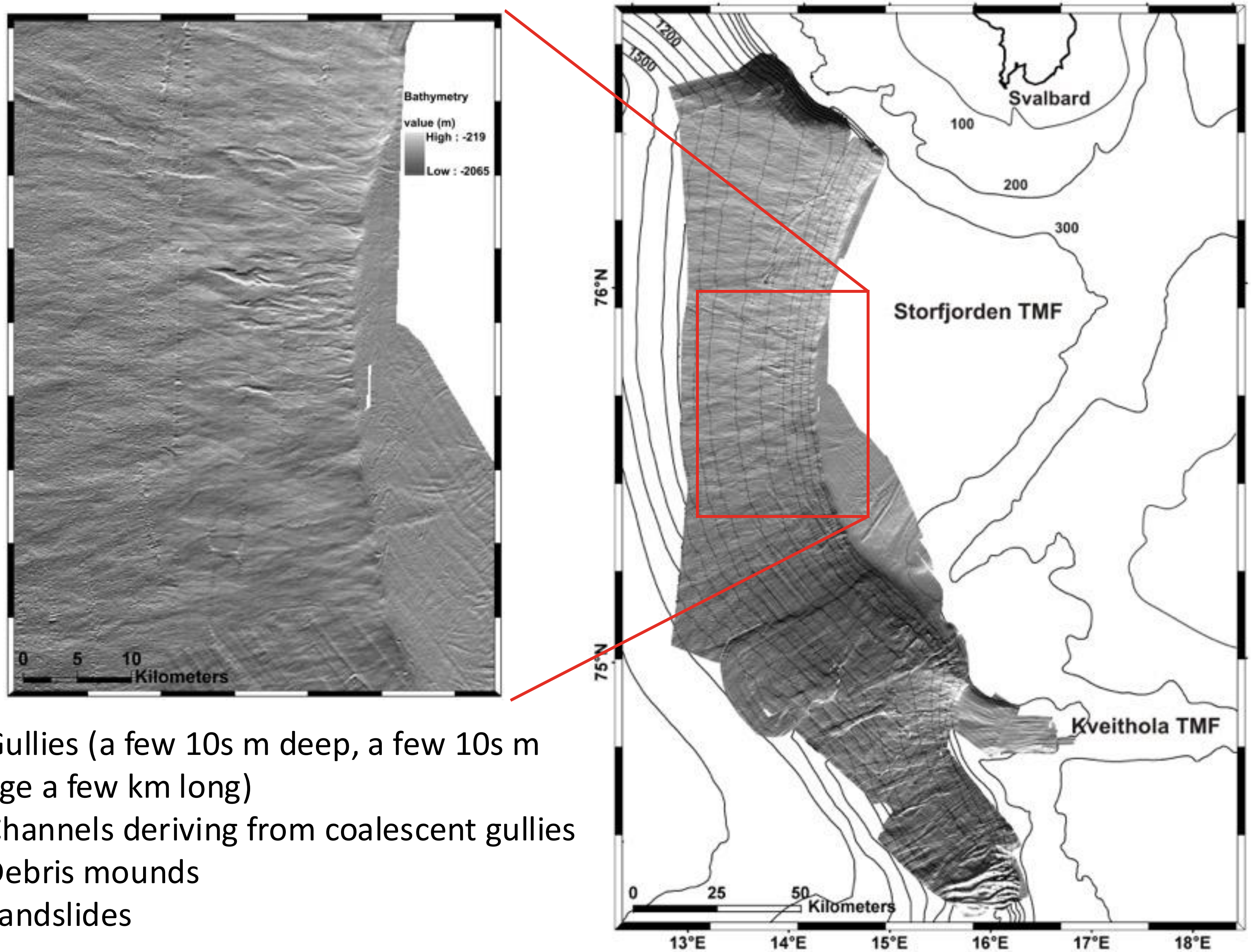


Ice Streams= Correnti di ghiaccio

Glacial trough= Fosse glaciali

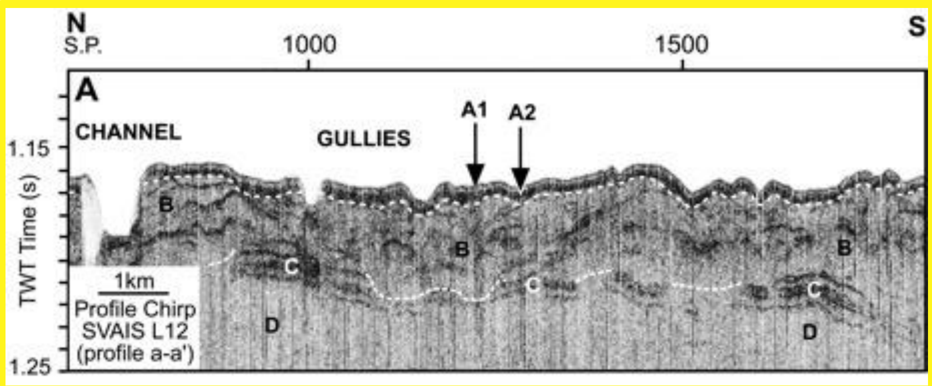
Trough Mouth Fans (TMFs)= Conoidi alla bocca della fossa glaciale

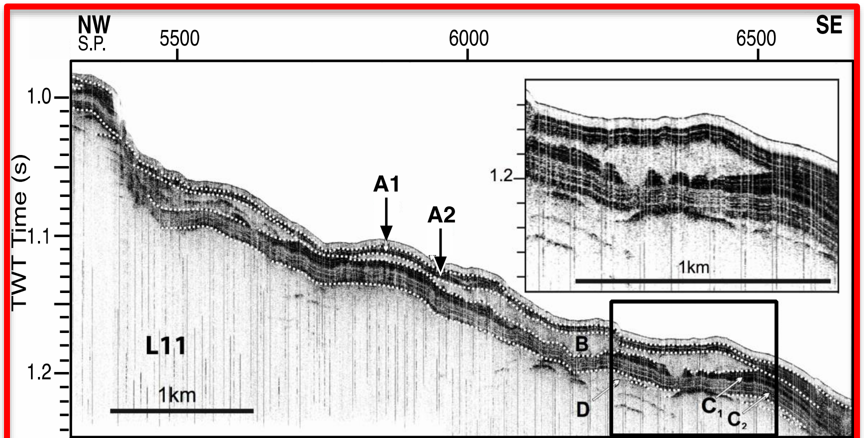


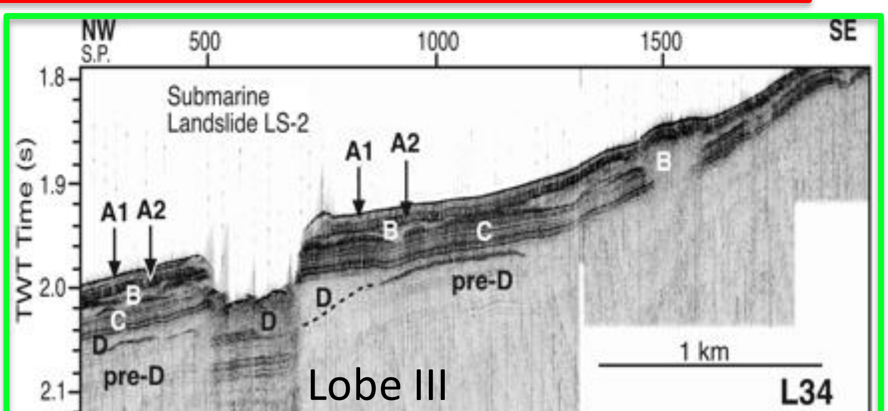


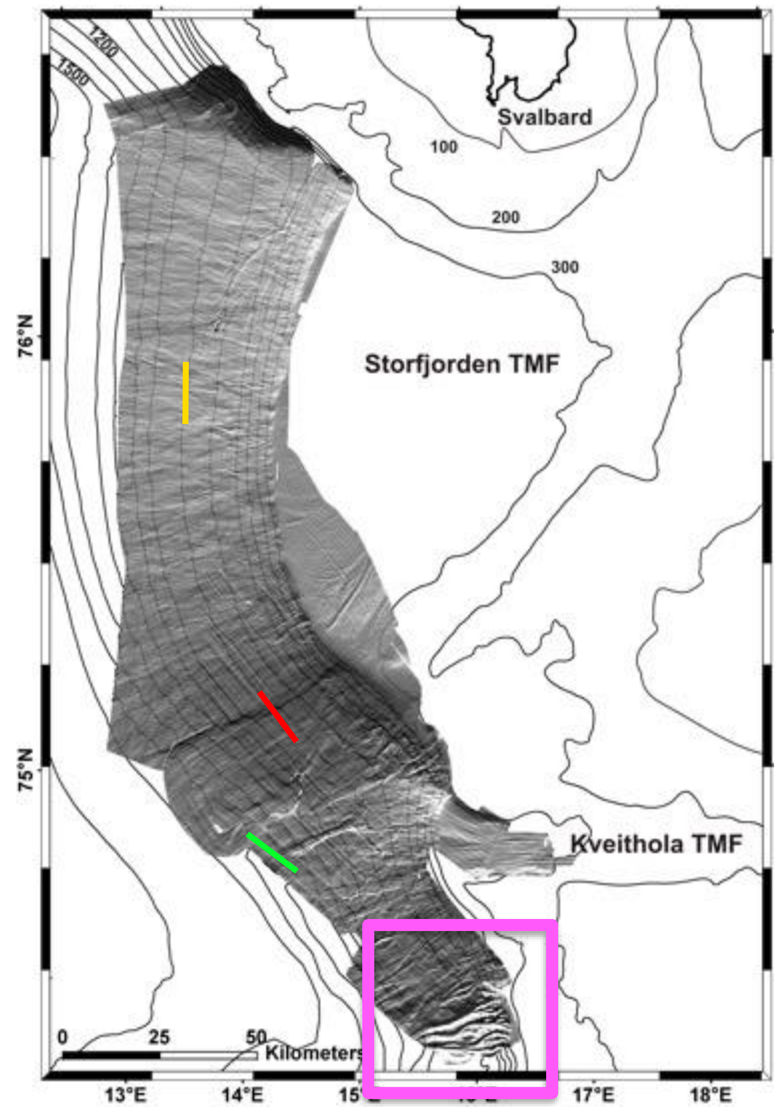
- Gullies (a few 10s m deep, a few 10s m large a few km long)
- Channels deriving from coalescent gullies
- Debris mounds
- Landslides

Continental slope architecture

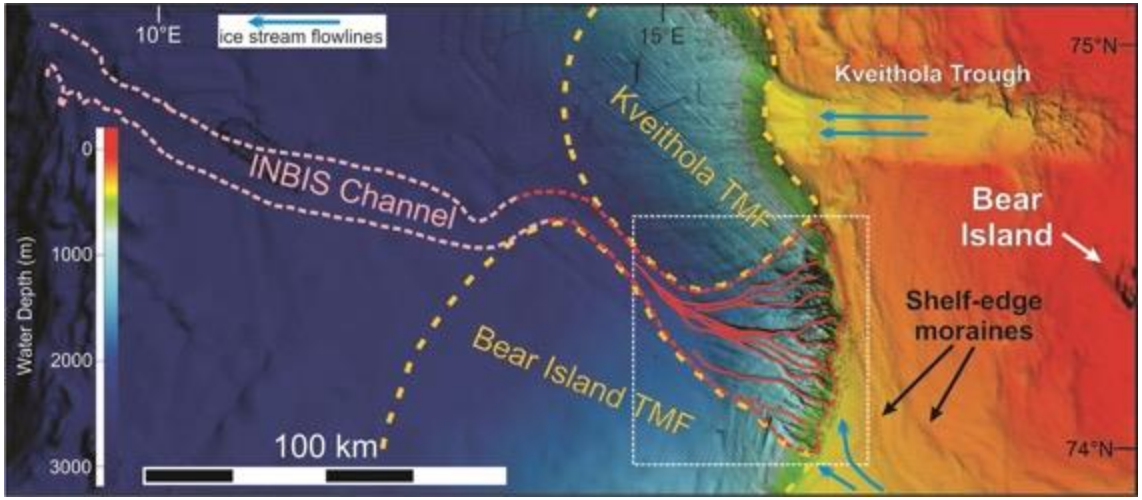


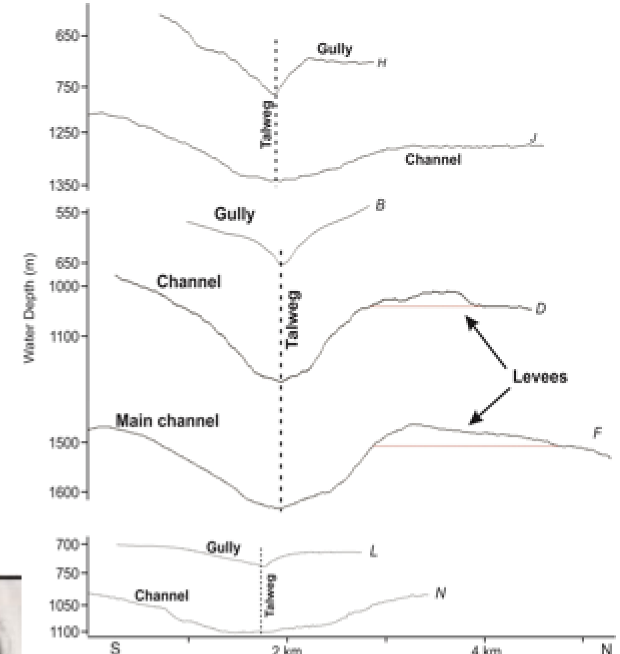


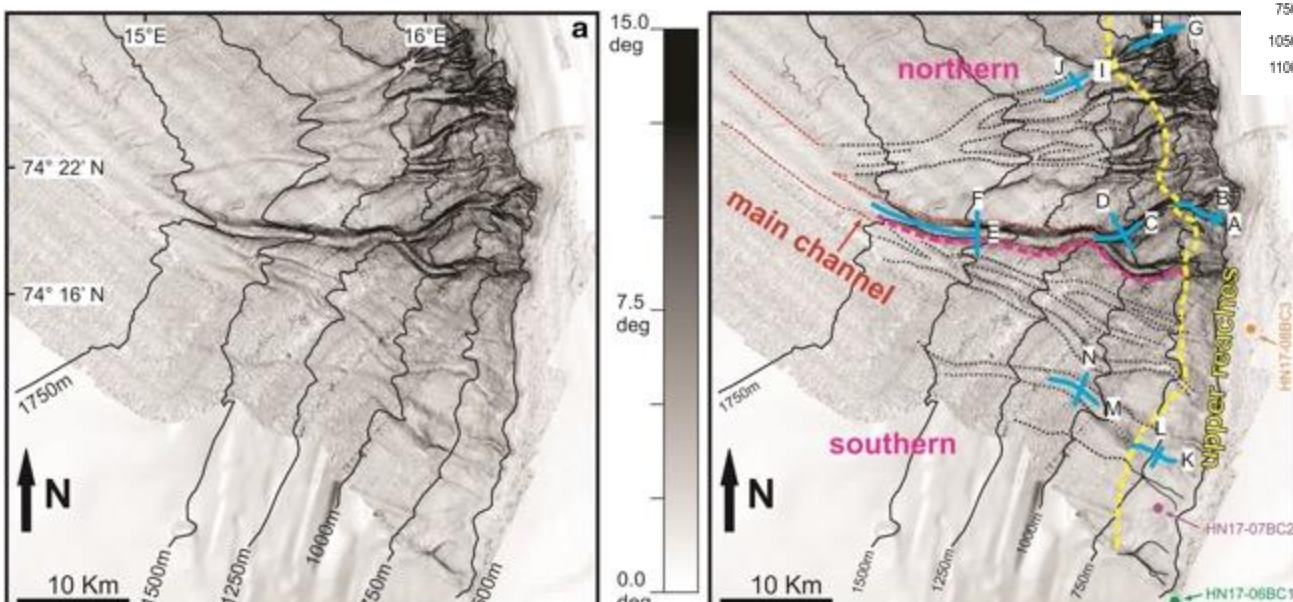




IN-Between-Ice Seets (INBIS) Channel

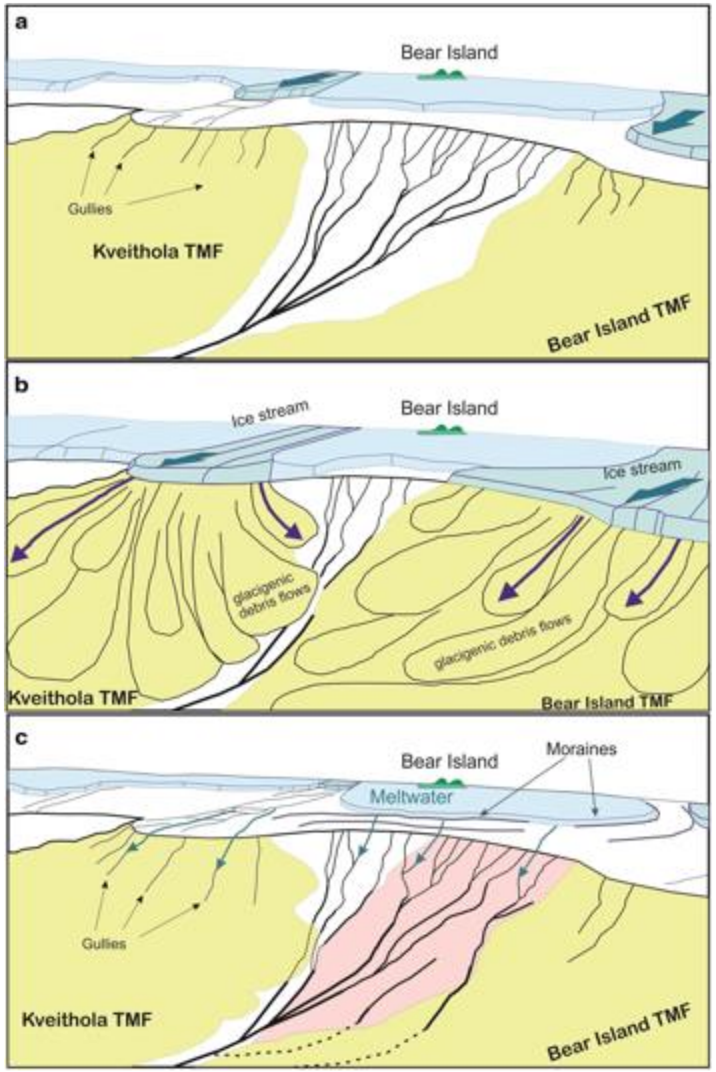






Gullies and Channels
down-slope
cross profiles

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

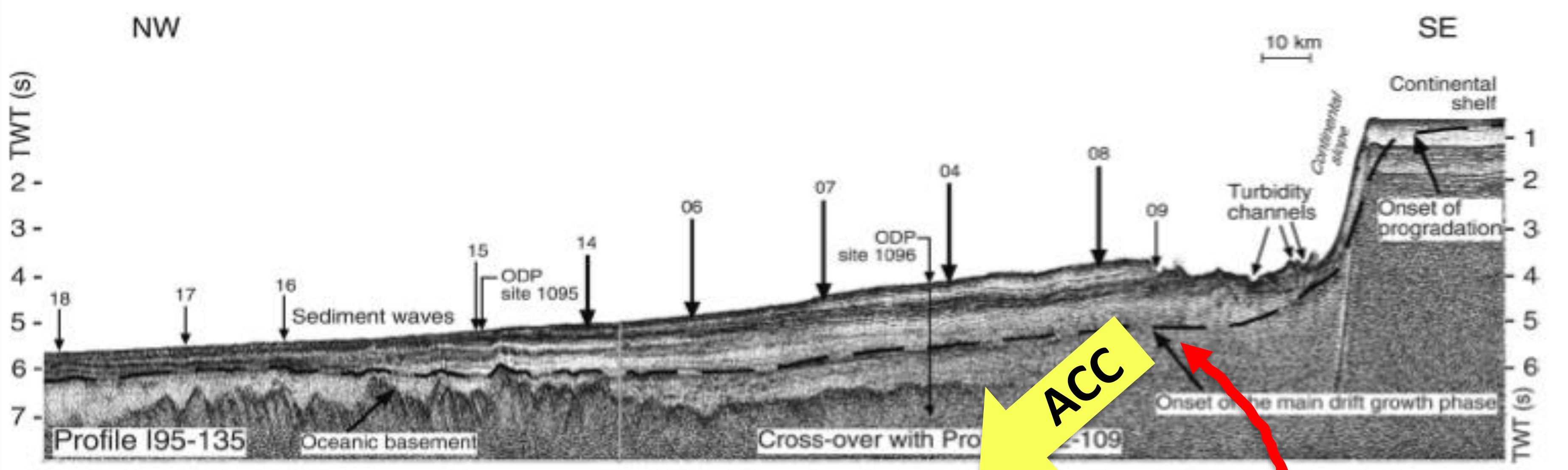


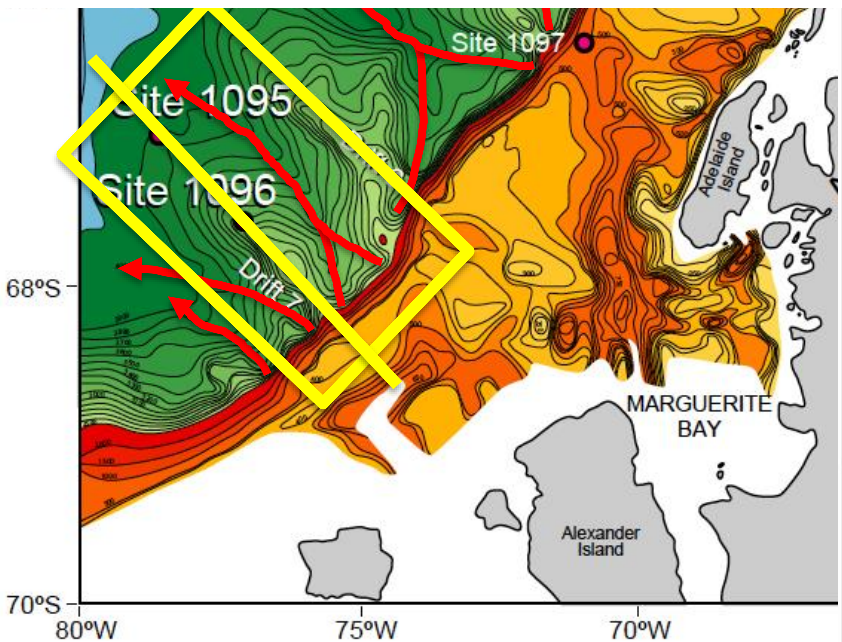
Rui et al., 2019_Arktos

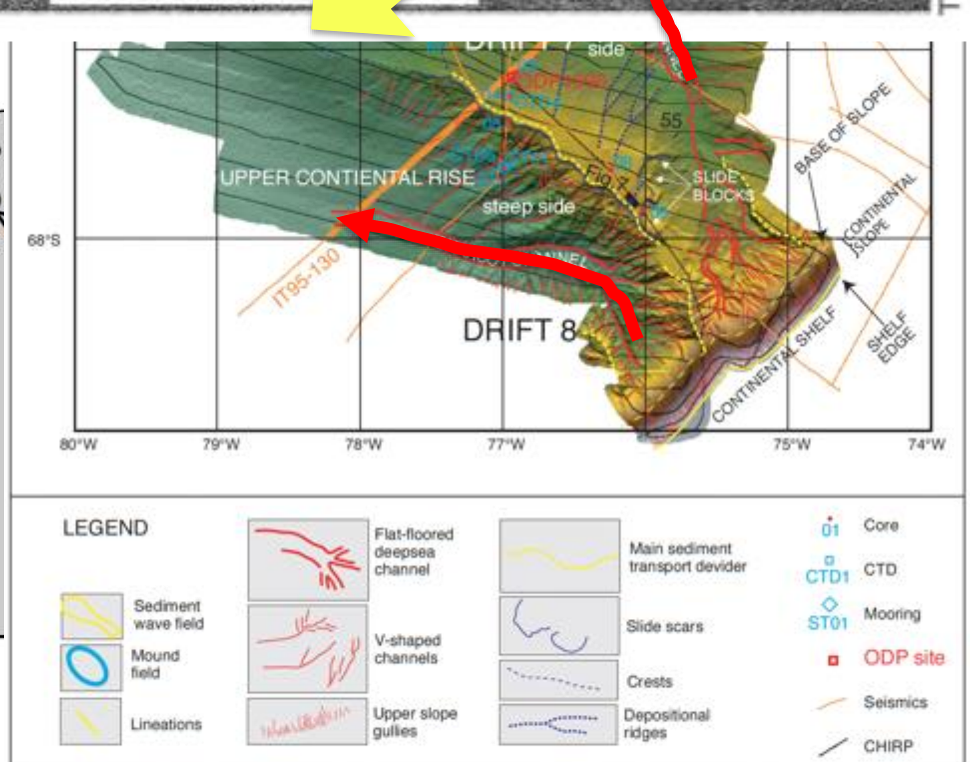
(a) pre-Last Glacial Maximum (LGM), slope sedimentation derived by pelagic settling and contour bottom currents

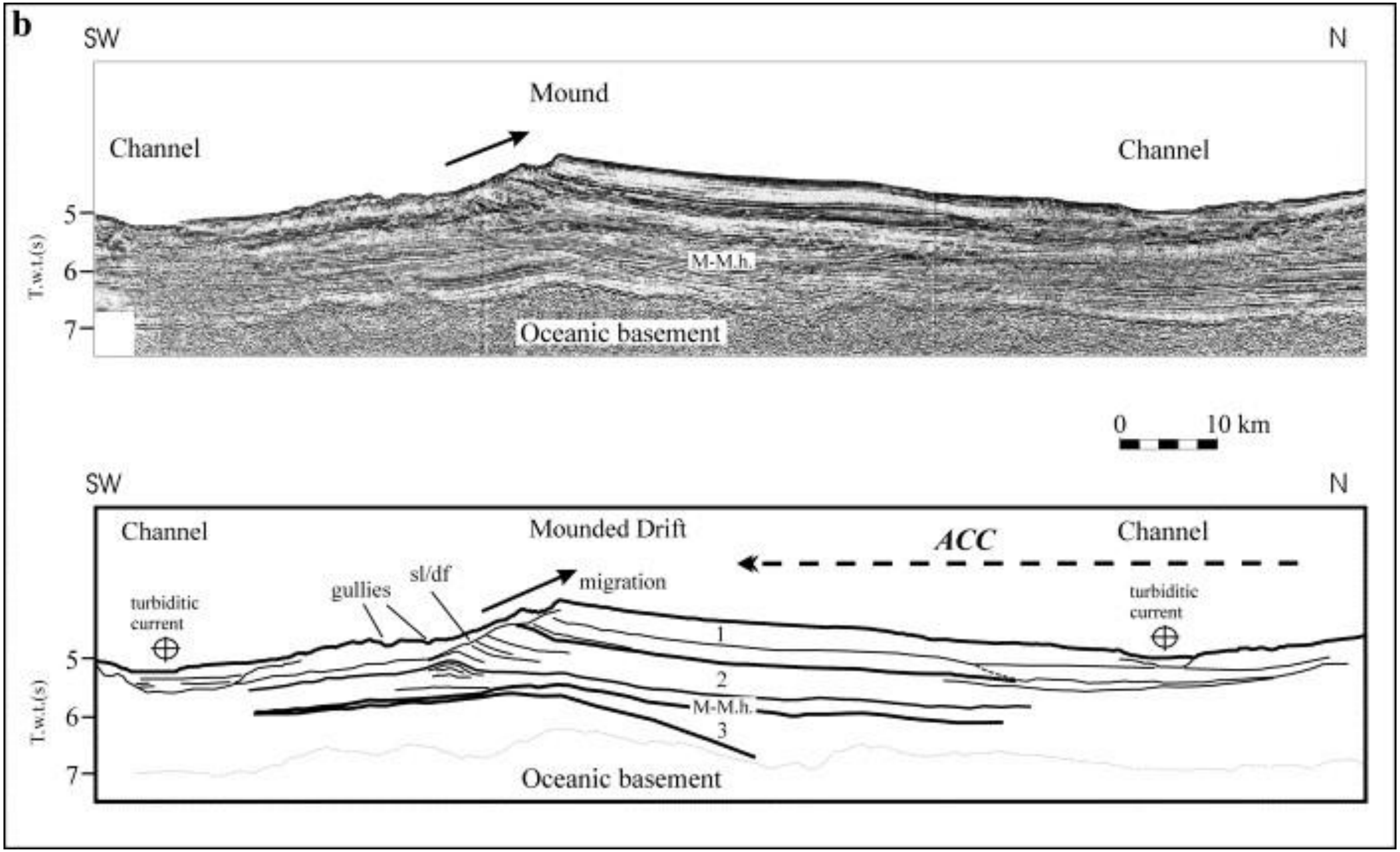
(b) LGM state with emplacement of glacigenic debrites forming depositional mounds (or lobes)

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


NW
SE
10 km
TWT (s)
Continental shelf
Continental slope
Turbidity channels
Onset of progradation
ODP site 1096
ODP site 1095
Sediment waves
Onset of the main drift growth phase
Profile I95-135
Oceanic basement
Cross-over with Pro
-109
ACC

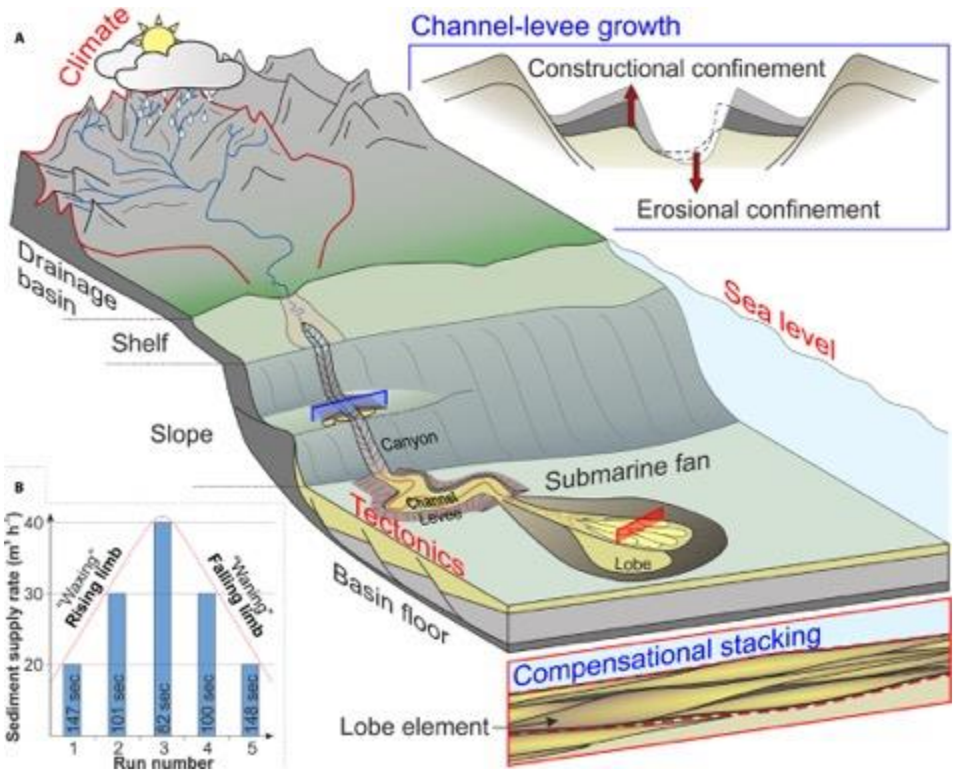

Site 1097
Site 1095
Site 1096
Drift 7
Adelaide Island
MARGUERITE BAY
Alexander Island
68°S
70°S
80°W
75°W
70°W


UPPER CONTIENTAL RISE
steep side
SLIDE BLOCKS
DRIFT 8
IT95-130
BASE OF SLOPE
CONTINENTAL SLOPE
SHELF EDGE
CONTINENTAL SHELF
68°S
80°W
79°W
78°W
77°W
75°W
74°W
LEGEND
Sediment wave field
Mound field
Lineations
Flat-floored deepsea channel
V-shaped channels
Upper slope gullies
Main sediment transport devider
Slide scars
Crests
Depositional ridges
Core
CTD
Mooring
ODP site
Seismics
CHIRP


b
SW
N
Mound
Channel
Channel
5
6
7
T.w.t.(s)
M-M.h.
Oceanic basement
0
10 km
SW
N
Channel
Mounded Drift
ACC
Channel
gullies
sl/df
migration
turbiditic current
turbiditic current
1
2
M-M.h.
3
5
6
7
T.w.t.(s)
Oceanic basement

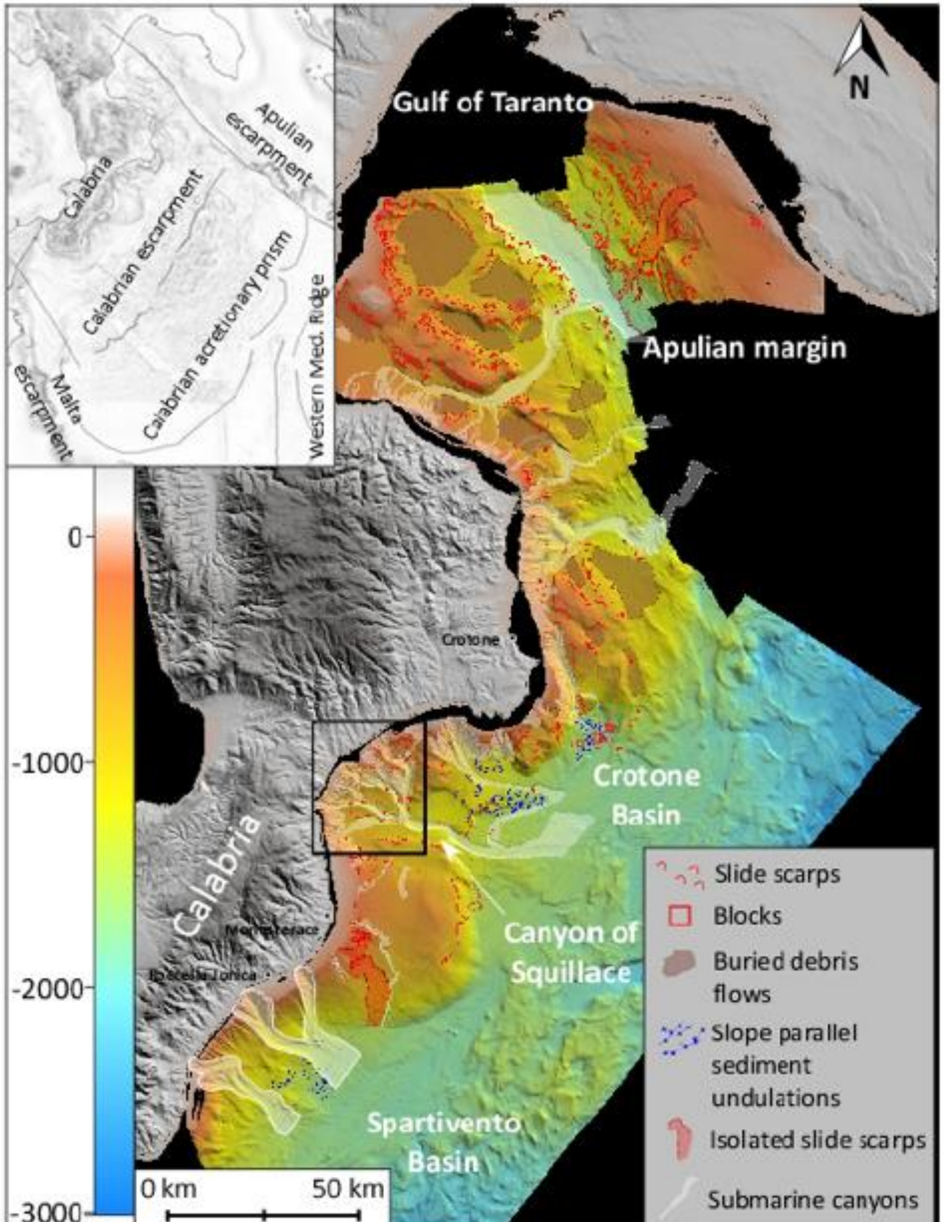
SLOPE SEDIMENTARY CONDUITS ON MID-LATITUDE MARGINS: CANYONS - CHANNELS - GULLIES

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).



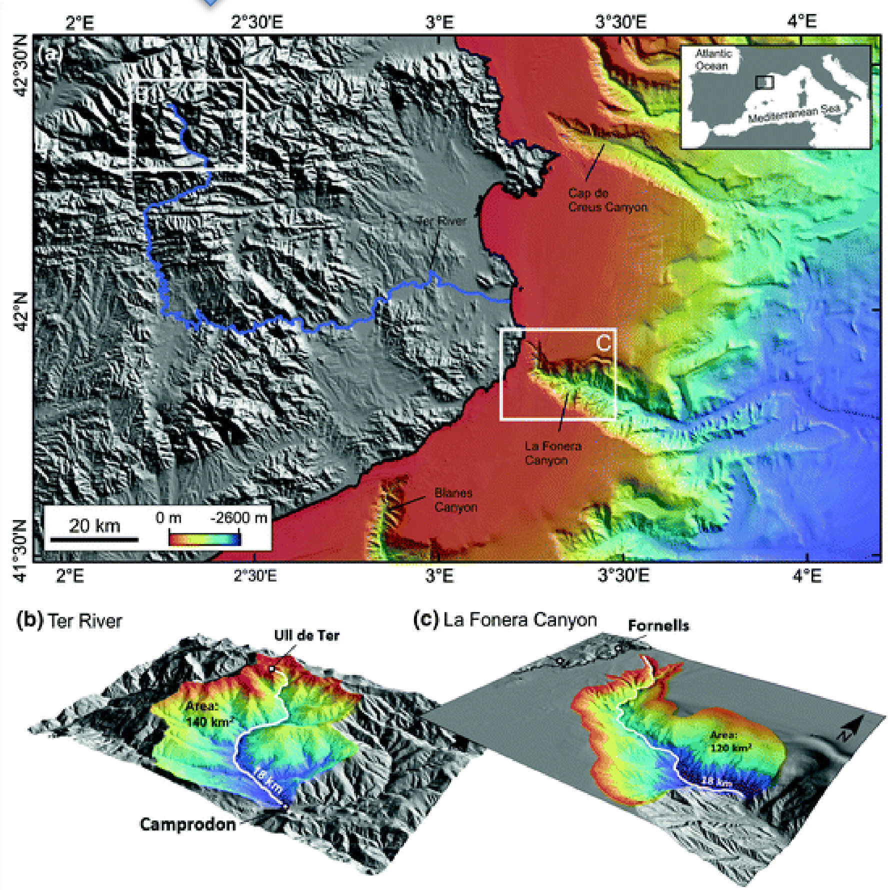
Submarine canyon: narrow steep-sided valleys cutting into continental slopes and rises. They can originate either within continental slopes or on continental shelves.

- Erosive or by-pass areas
- High gradient, strait conduict
- 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

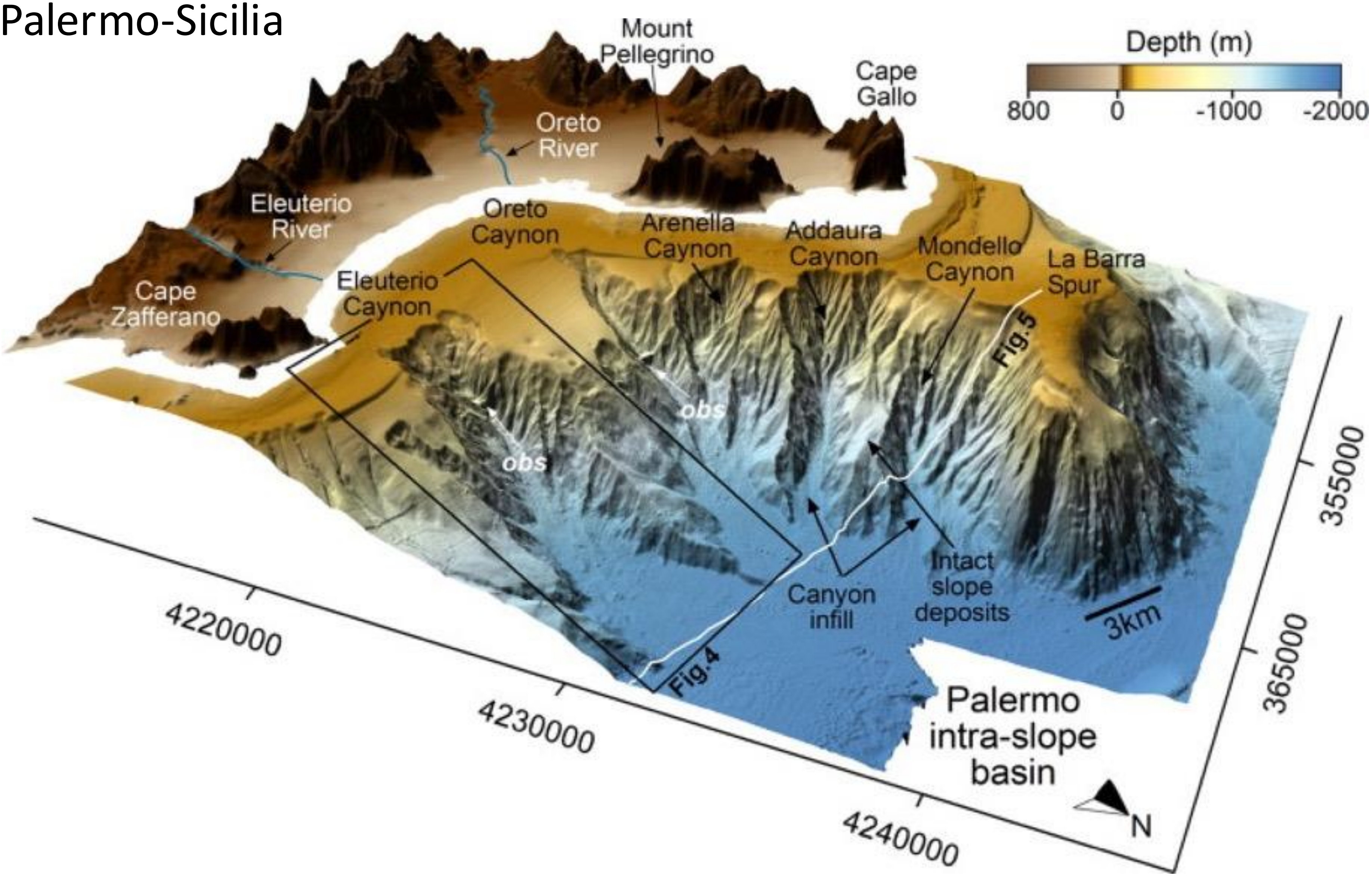


Margine ionico della Calabria

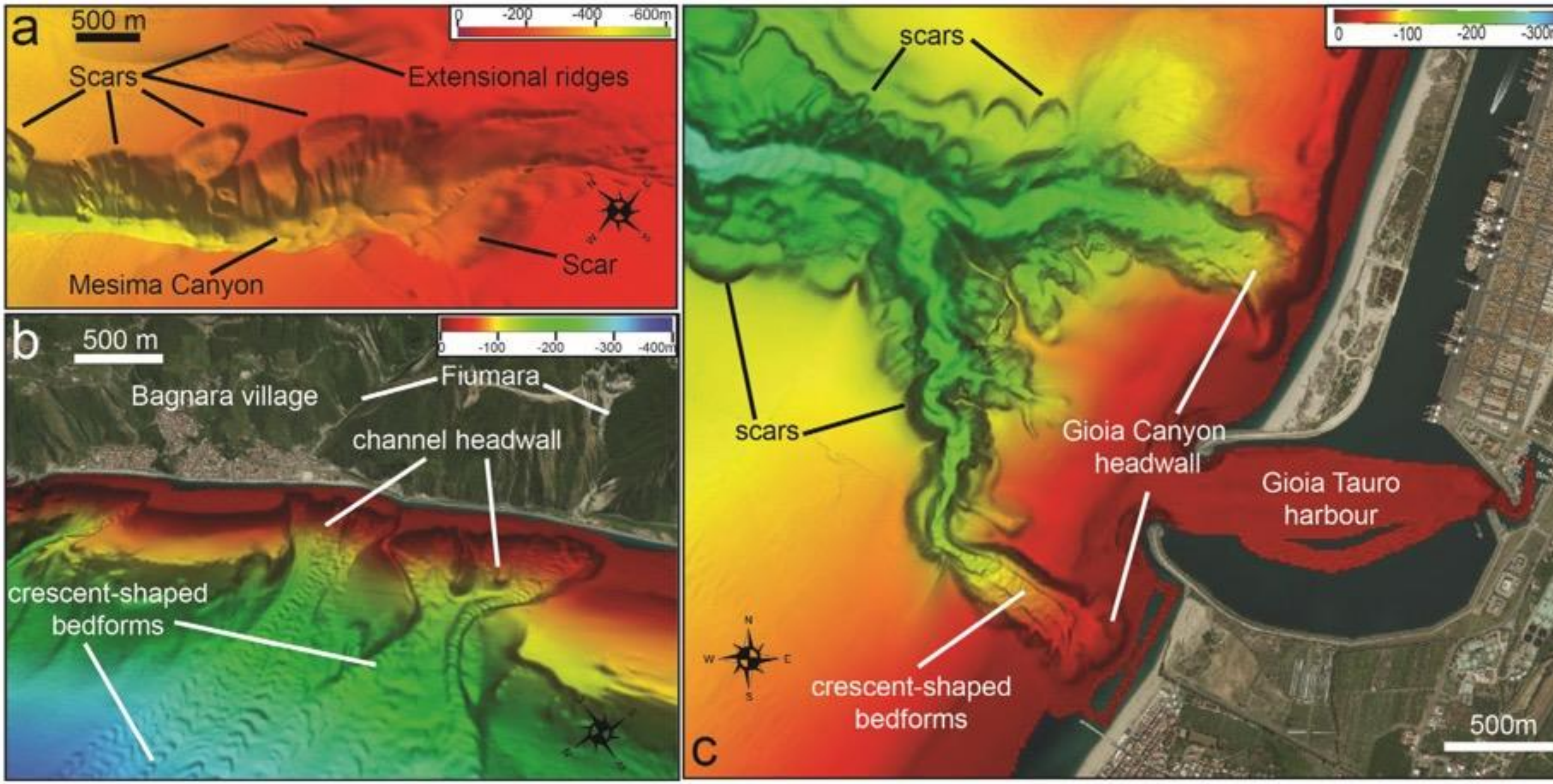
Margine Catalano

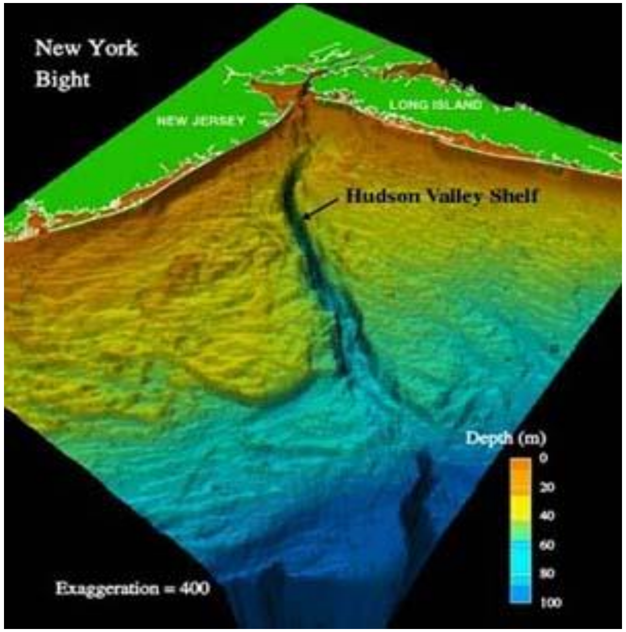


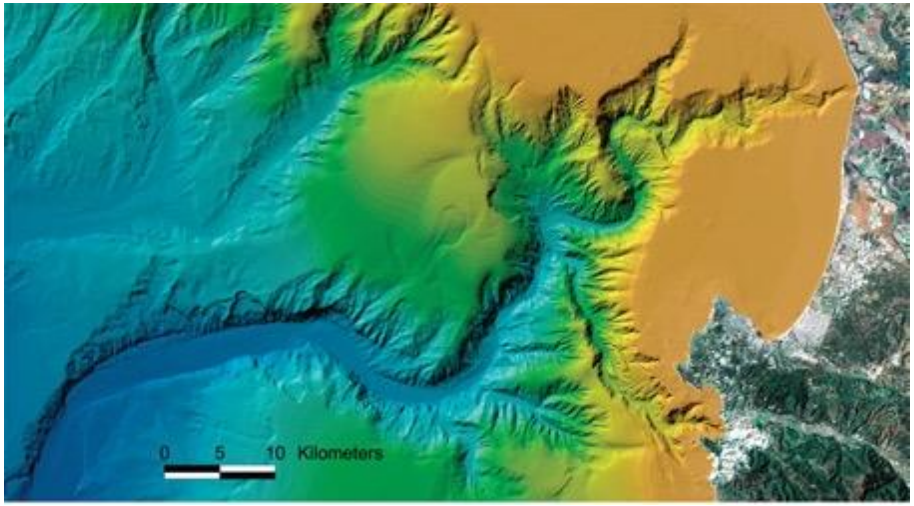
Palermo-Sicilia



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

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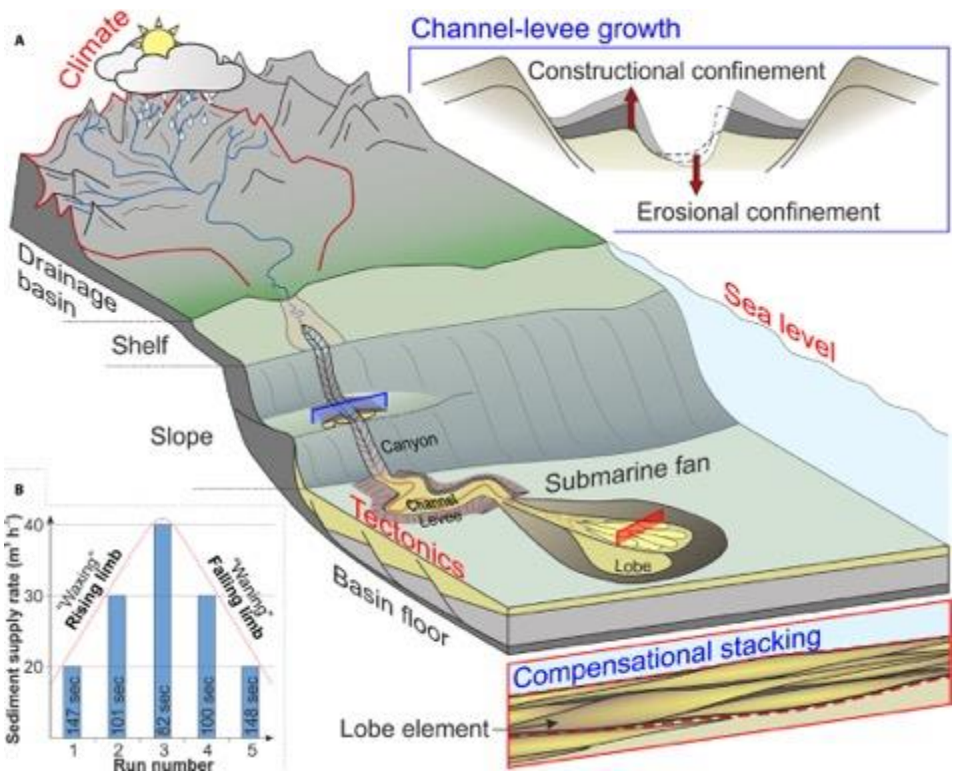
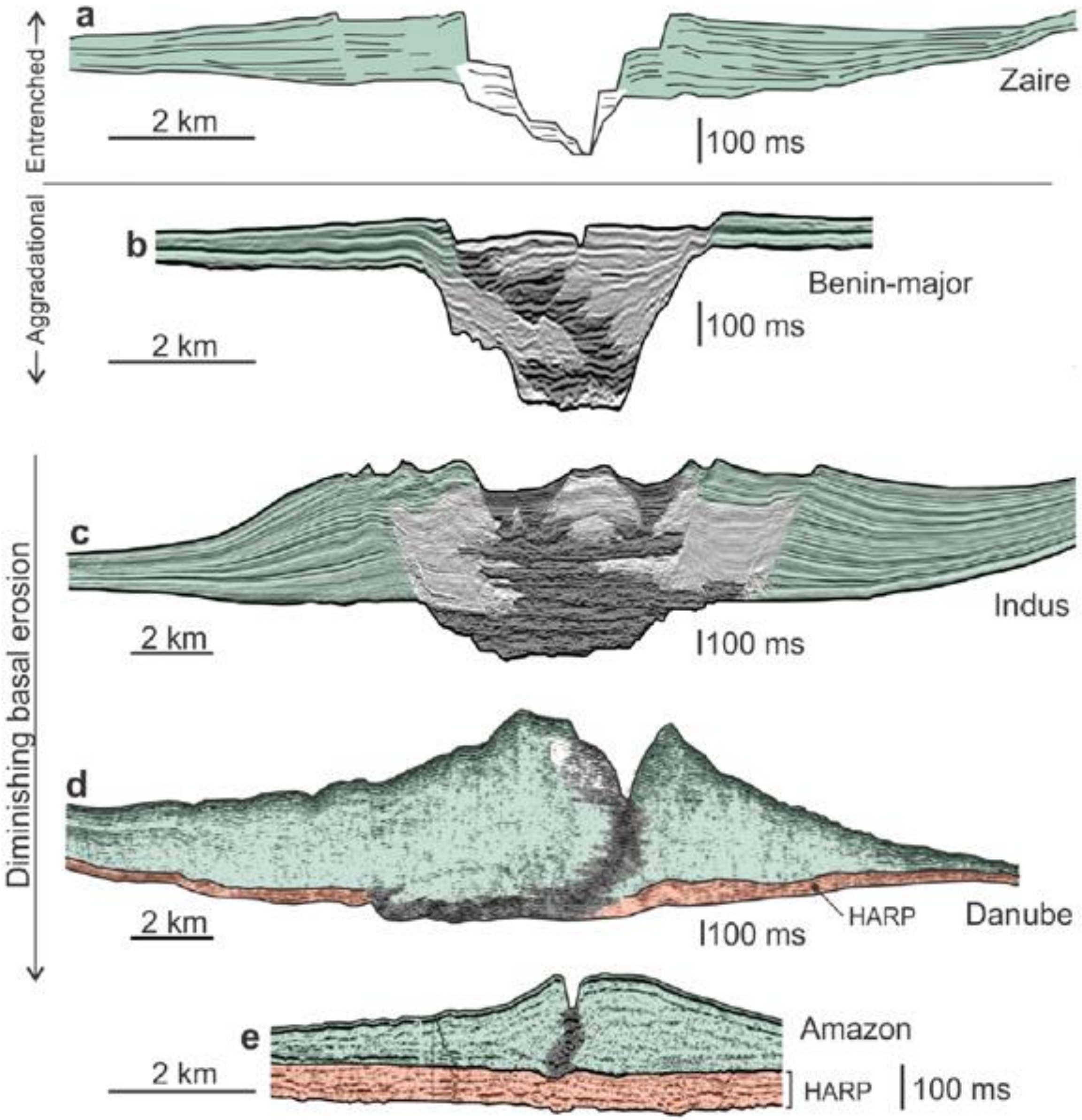


Submarine channels: wide flat valley flanked by depositional channel's levees They originate at the base of continental slopes or on continental rises.

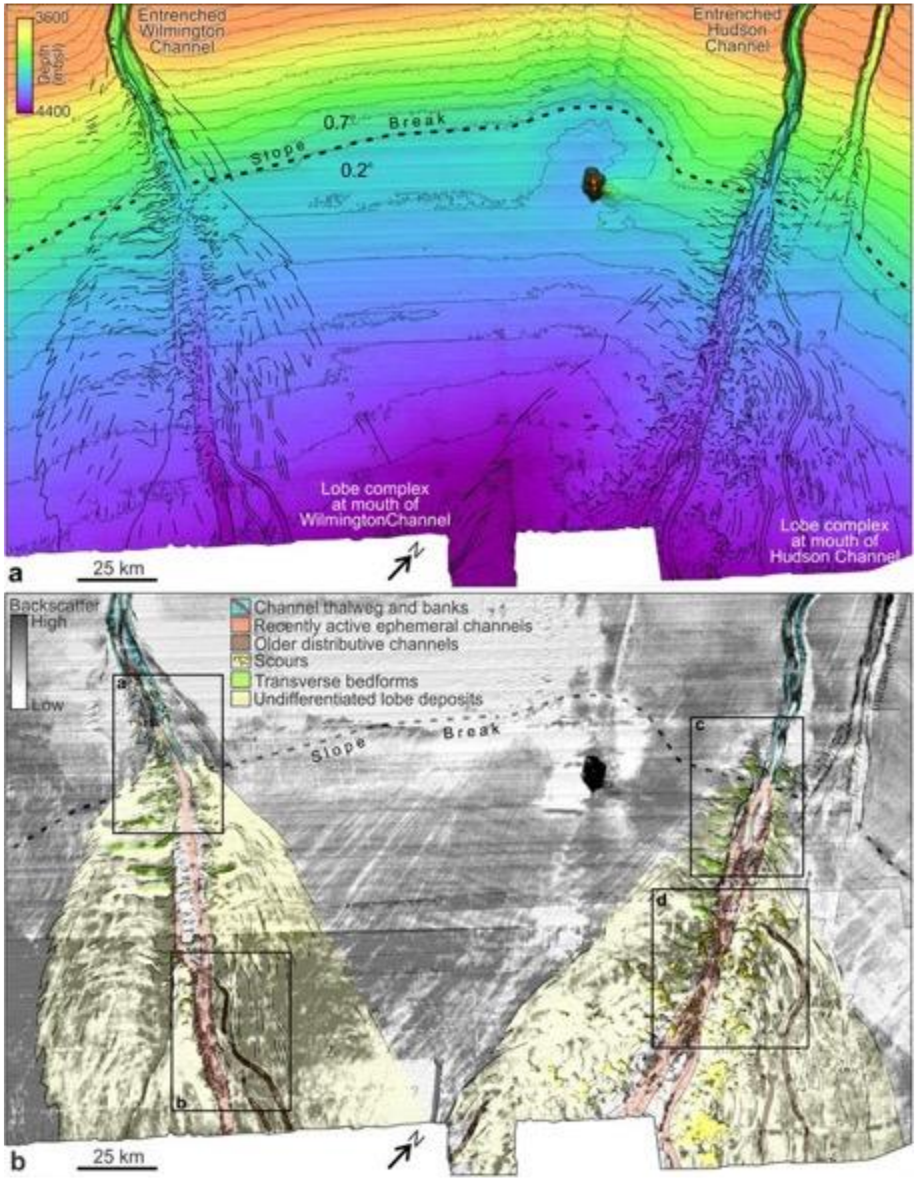
- Initially by-pass, evolve as depositional areas
- U-shaped cross profile flanked by
- Well developed channel's levees (overbank deposits)
- Often sinuous conduit
- 10s-100s km wide
- 10s-1000s km long
- Internal and outer levee sides often hosting slumps/failure



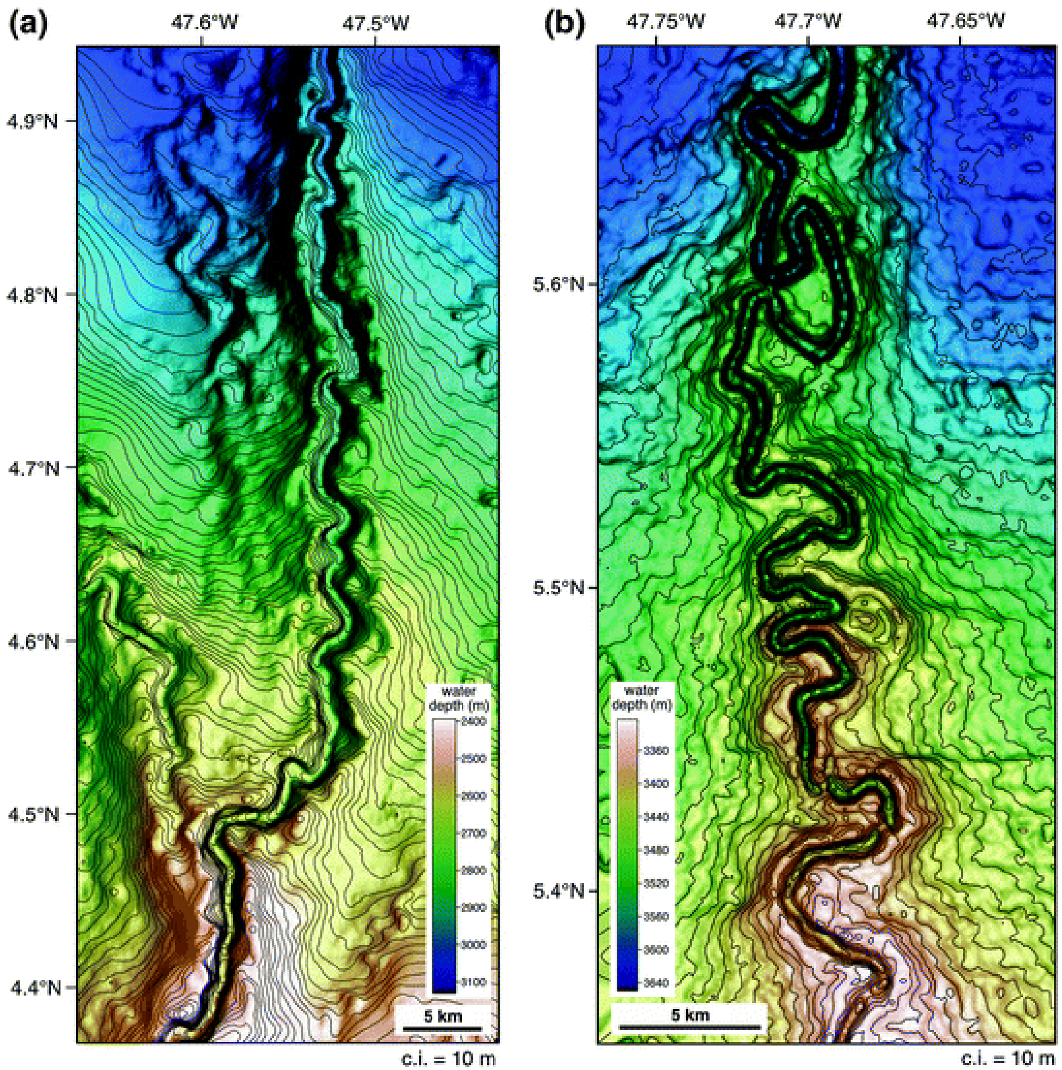
Deptuck & Sylvester, 2018 Submarine Fans and their channels, levees, and lobes. *In*: Submarine Geomorphology, Springer.

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

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

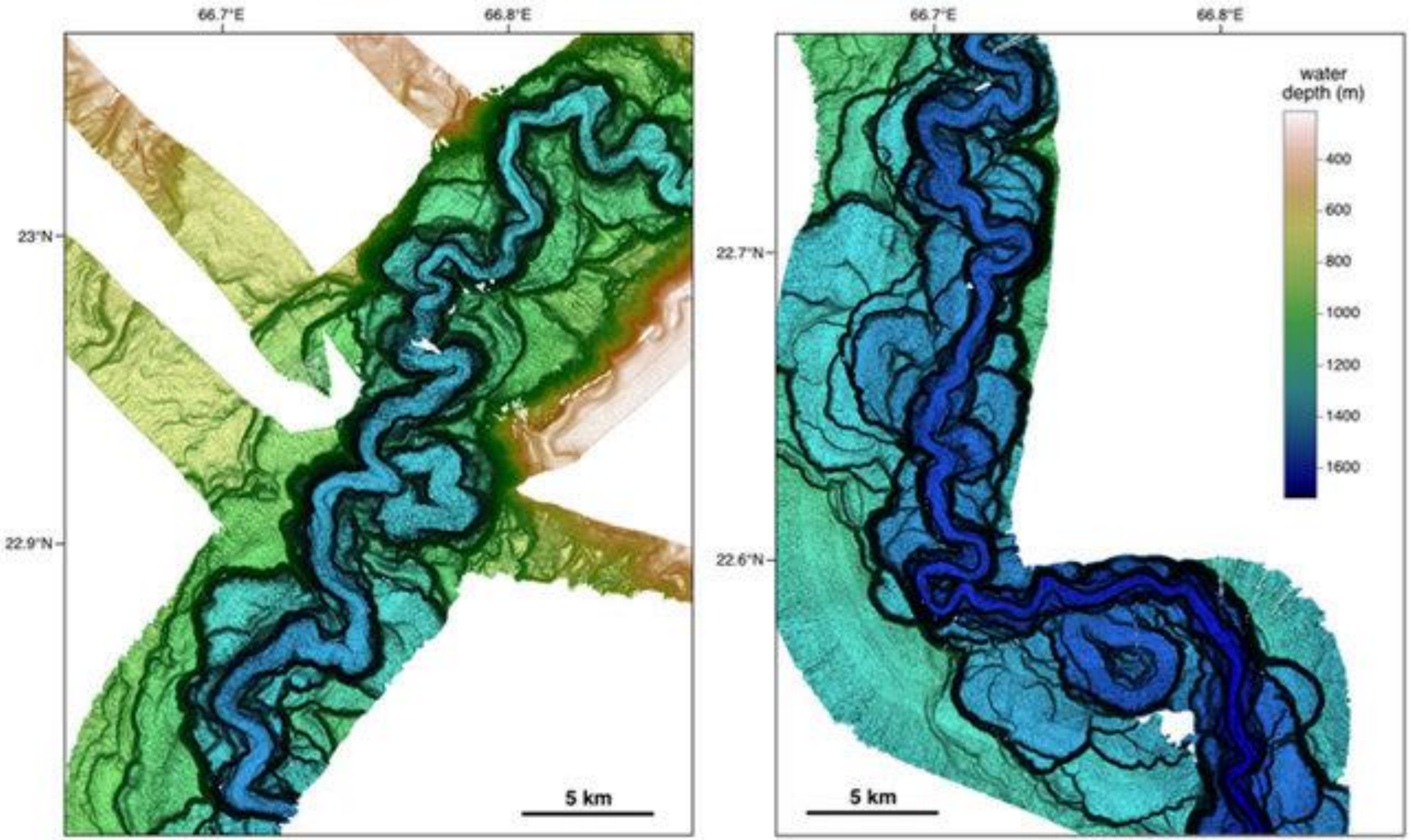


Gardner, 2004: Interpretation of geomorphic features near the channel-lobe transition seaward of Wilmington and **Hudson channels**. a bathymetry; b backscatter.

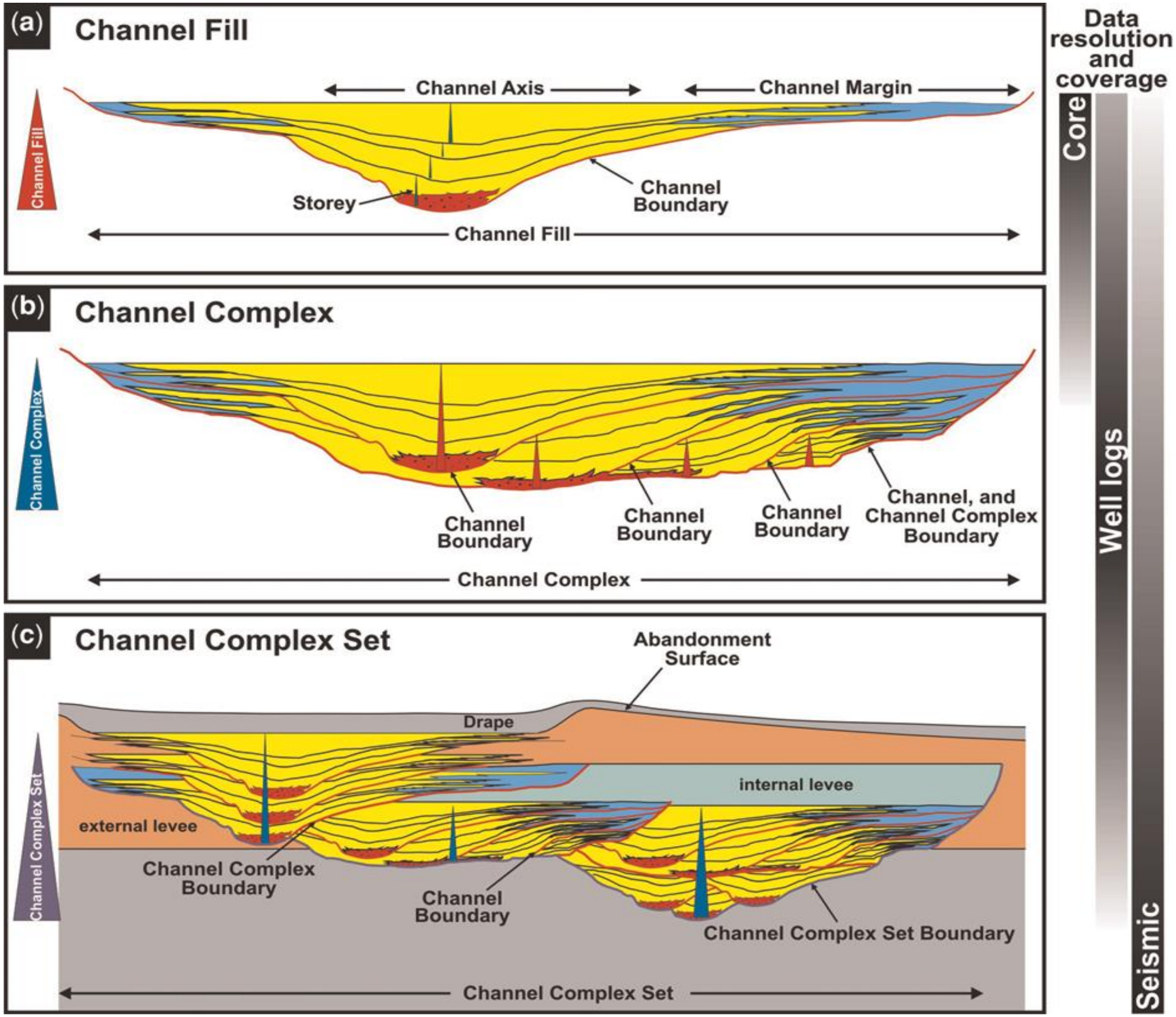


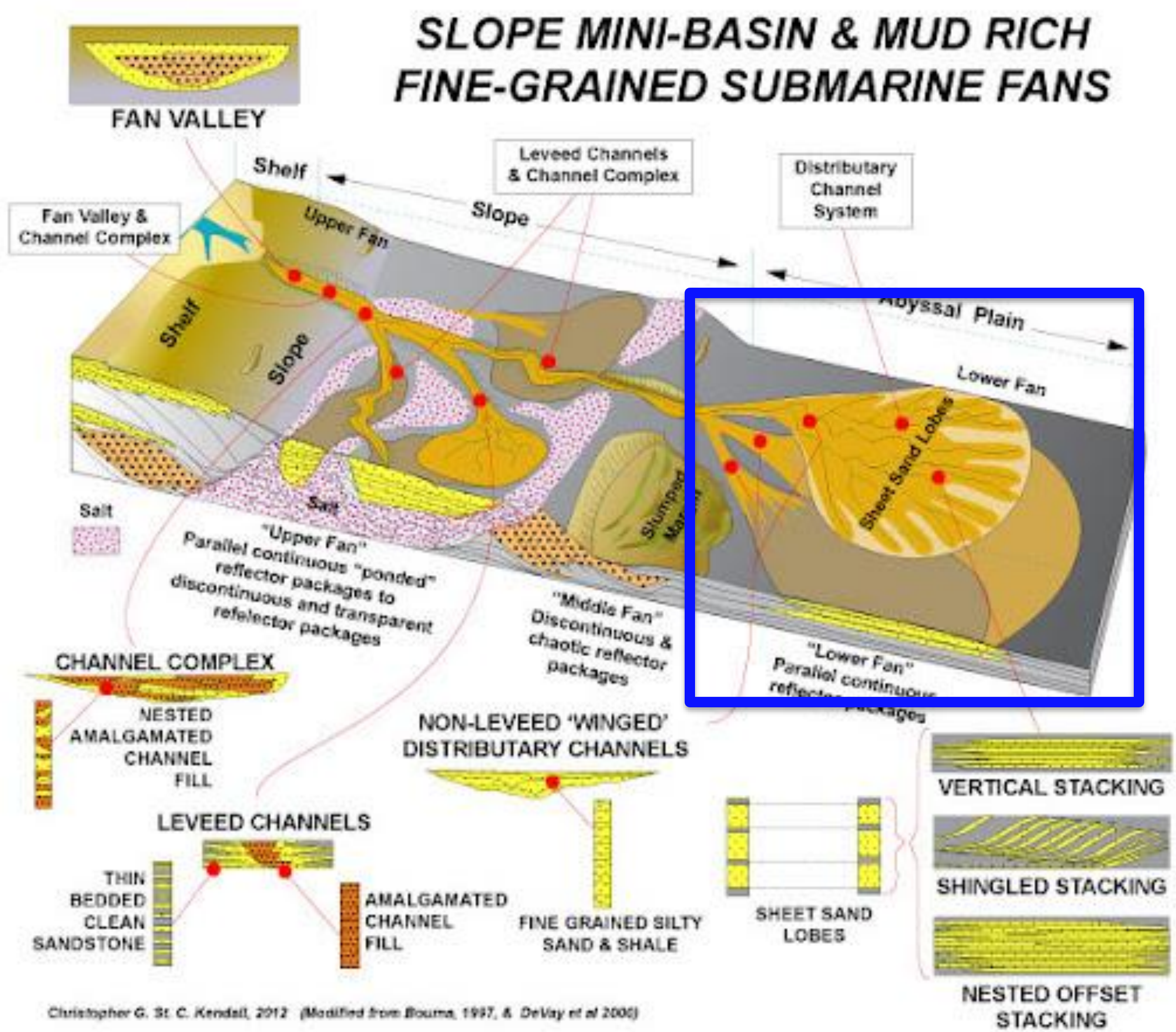
Sinuous submarine channels on the **Amazon Fan**.

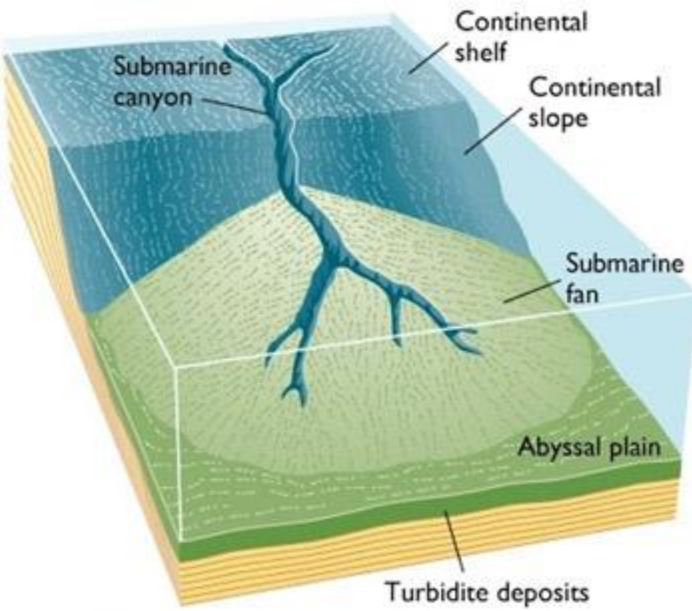
(a) Avulsion on the upper fan,
(b) Higher sinuosity and recent and incipient cutoffs on the middle fan. Bathymetry data from NOAA



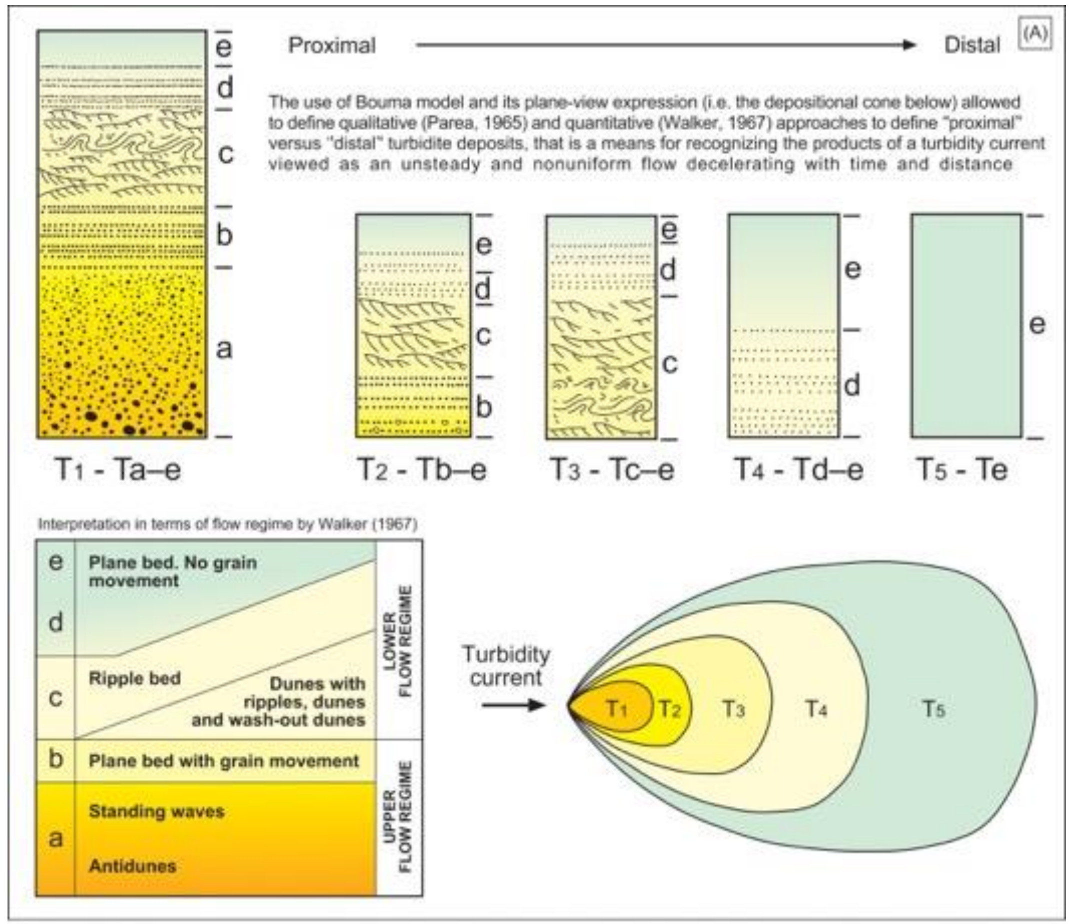
Morphology of large channel-levee systems: the canyon-channel transition zone on the upper part of the **Indus Fan**, with terraces and cutoffs. Data from Clift and Henstock (2015).

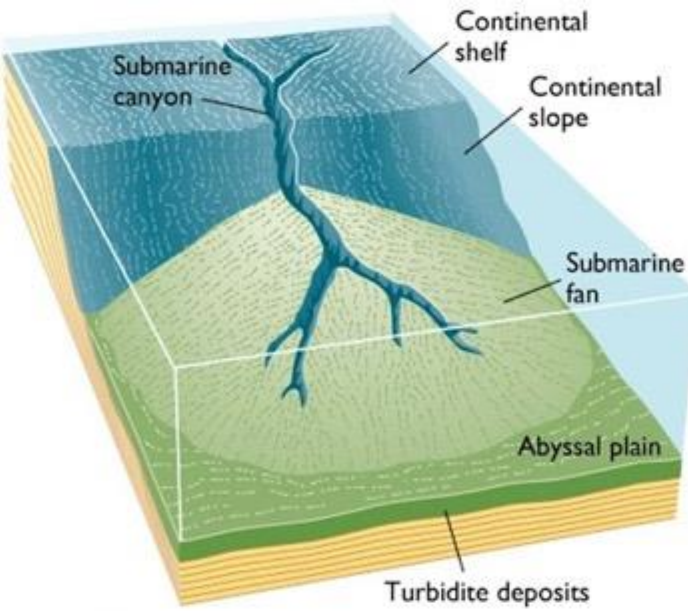

(a)
Channel Fill
Channel Axis
Channel Margin
Channel Fill
Storey
Channel Boundary
Channel Fill
(b)
Channel Complex
Channel Complex
Channel Boundary
Channel Boundary
Channel Boundary
Channel, and Channel Complex Boundary
Channel Complex
(c)
Channel Complex Set
Abandonment Surface
Drape
internal levee
external levee
Channel Complex Set
Channel Complex Boundary
Channel Boundary
Channel Complex Set Boundary
Channel Complex Set
Data resolution and coverage
Core
Well logs
Seismic


SLOPE MINI-BASIN & MUD RICH FINE-GRAINED SUBMARINE FANS
FAN VALLEY
Shelf
Slope
Leveed Channels & Channel Complex
Distributary Channel System
Fan Valley & Channel Complex
Upper Fan
Abyssal Plain
Lower Fan
Shelf
Slope
Sheet Sand Lobes
Salt
Salt
"Upper Fan" Parallel continuous "ponded" reflector packages to discontinuous and transparent refelector packages
"Middle Fan" Discontinuous & chaotic reflector packages
"Lower Fan" Parallel continuous
CHANNEL COMPLEX
NESTED AMALGAMATED CHANNEL FILL
NON-LEVEED 'WINGED' DISTRIBUTARY CHANNELS
LEVEED CHANNELS
THIN BEDDED CLEAN SANDSTONE
AMALGAMATED CHANNEL FILL
FINE GRAINED SILTY SAND & SHALE
SHEET SAND LOBES
VERTICAL STACKING
SHINGLED STACKING
NESTED OFFSET STACKING
Christopher G. St. C. Kendall, 2012 (Modified from Bouma, 1997, & DeVay et al 2000)

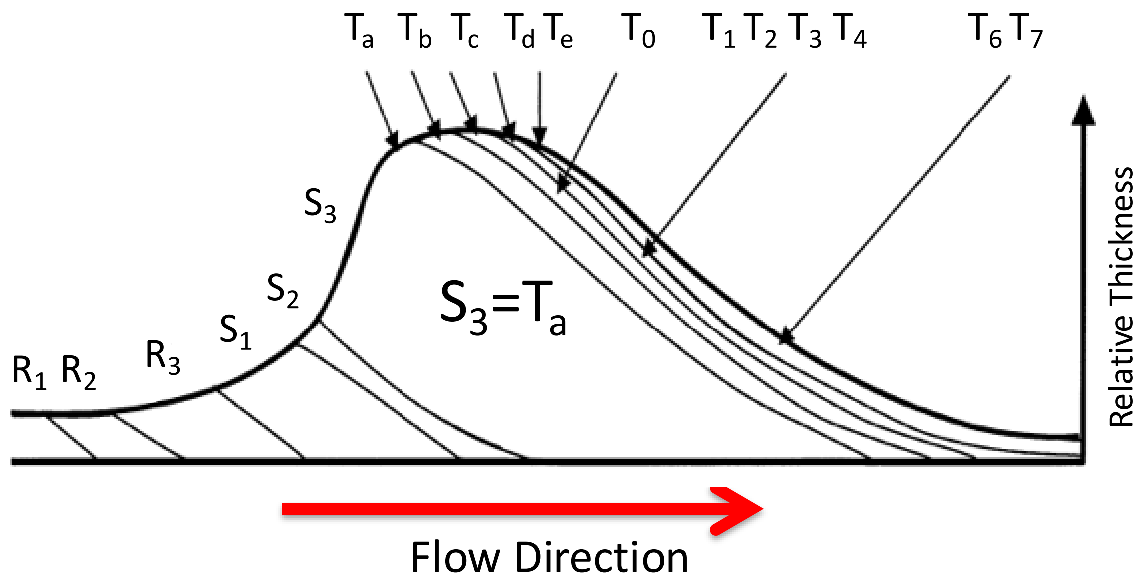


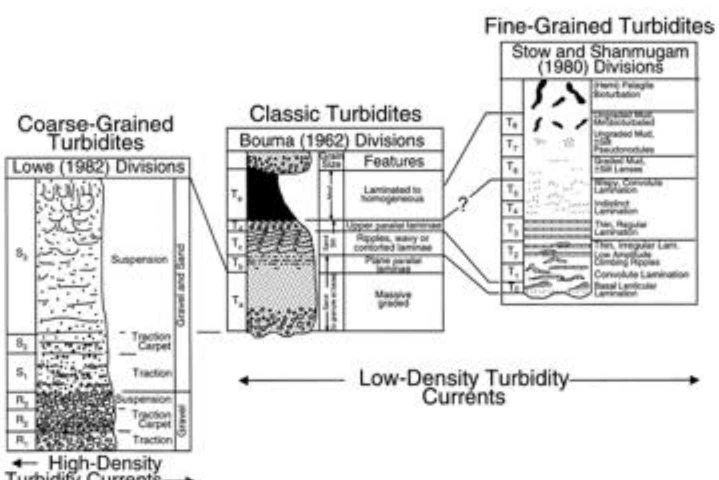
Depositional cone

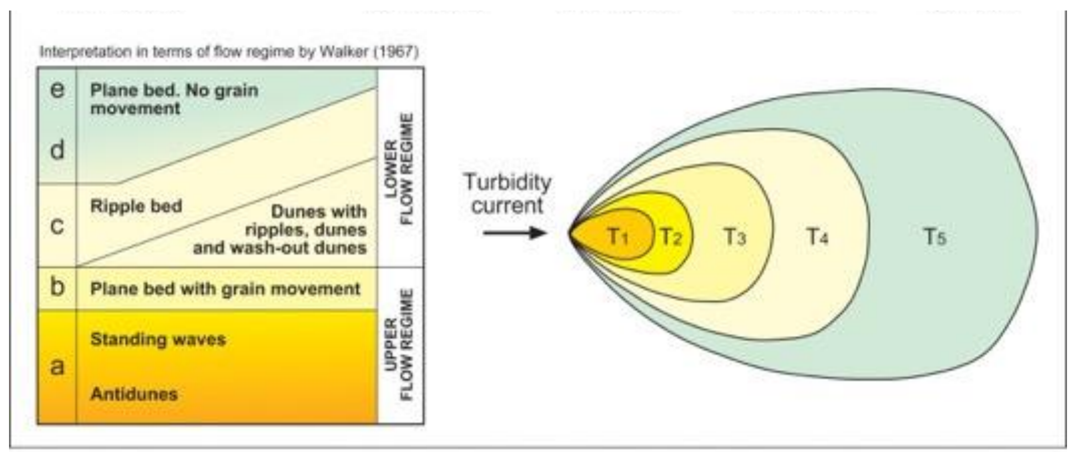




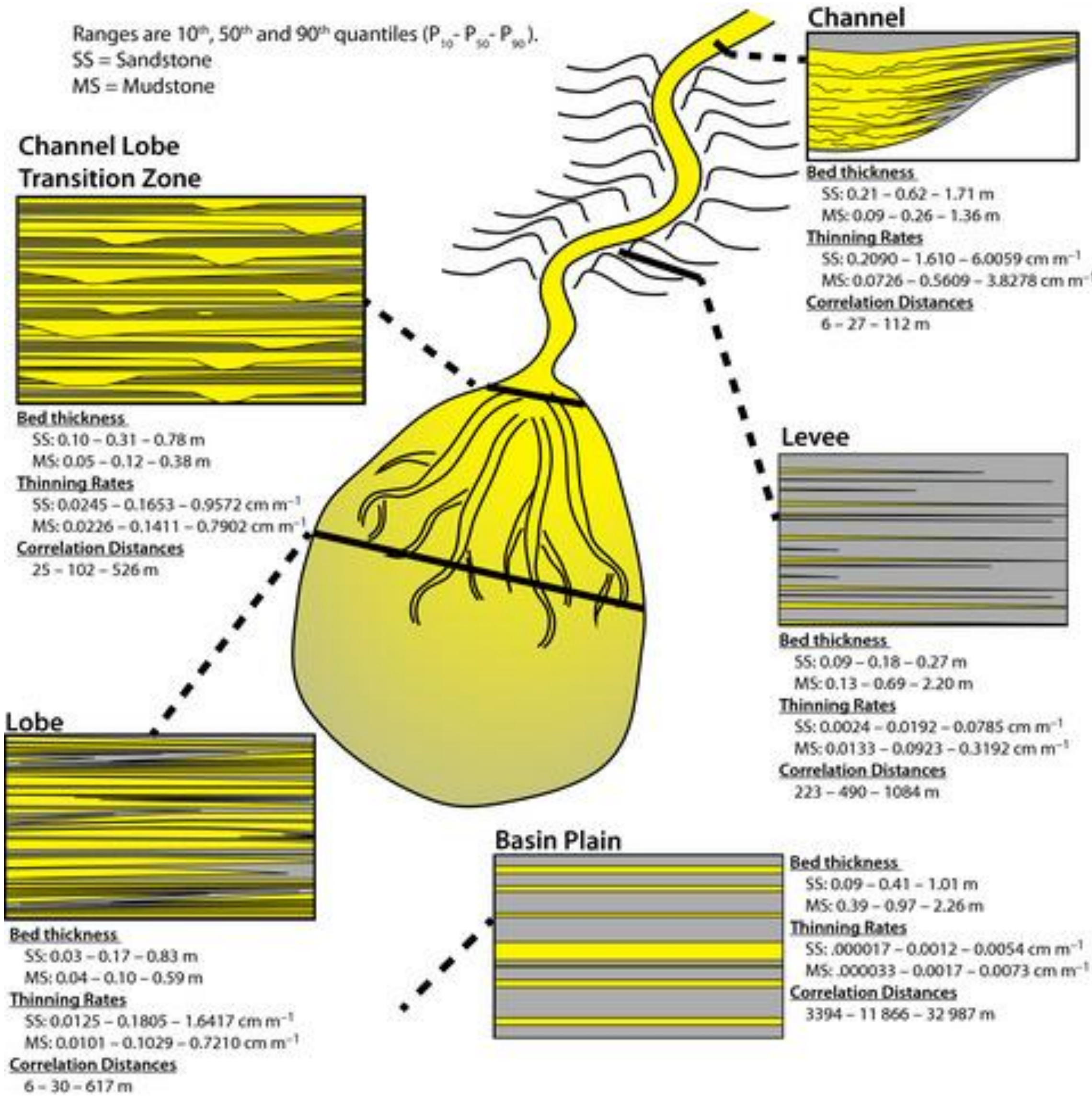
Depositional cone





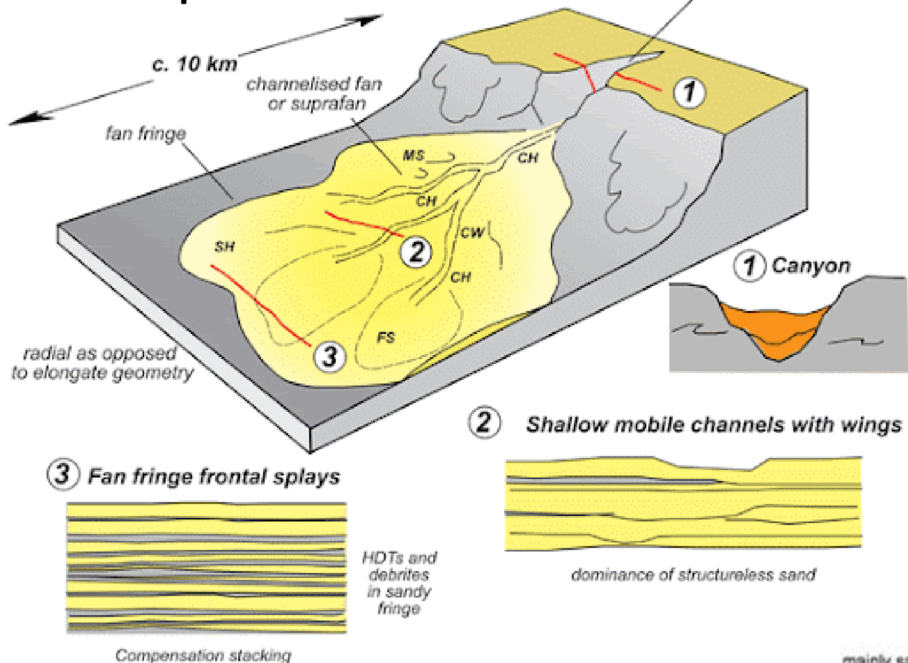


SEDIMENT FACIES in channel-deep sea fan

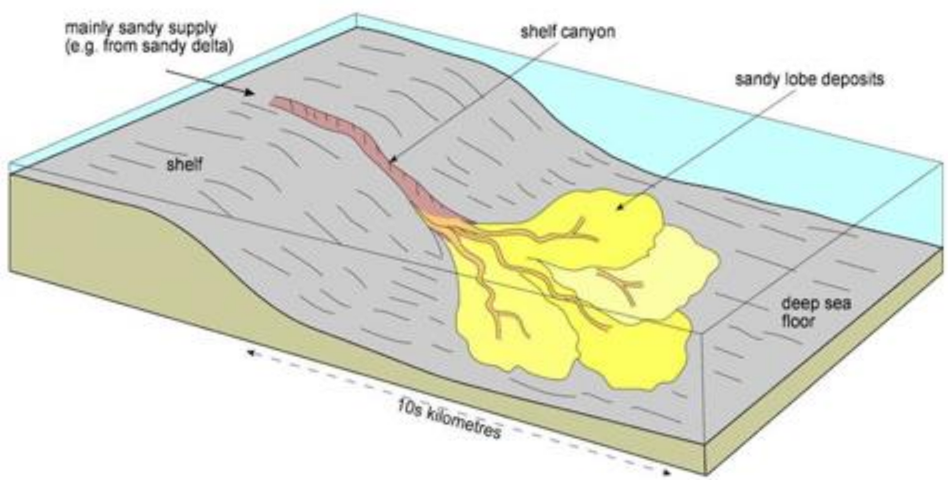


NUMBER and LOCATION of lobes forming deep sea fans

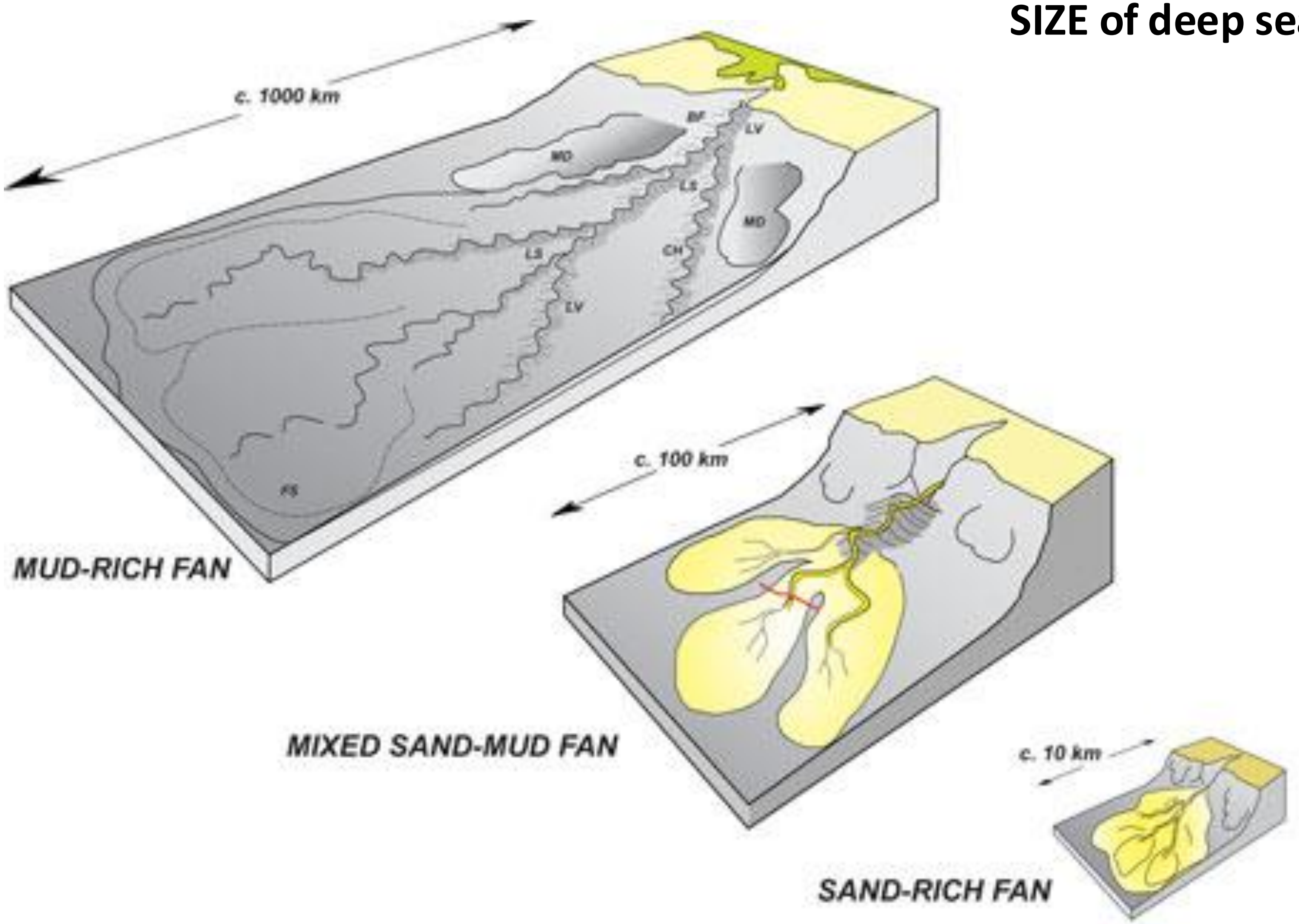
Pluri-lobi separati



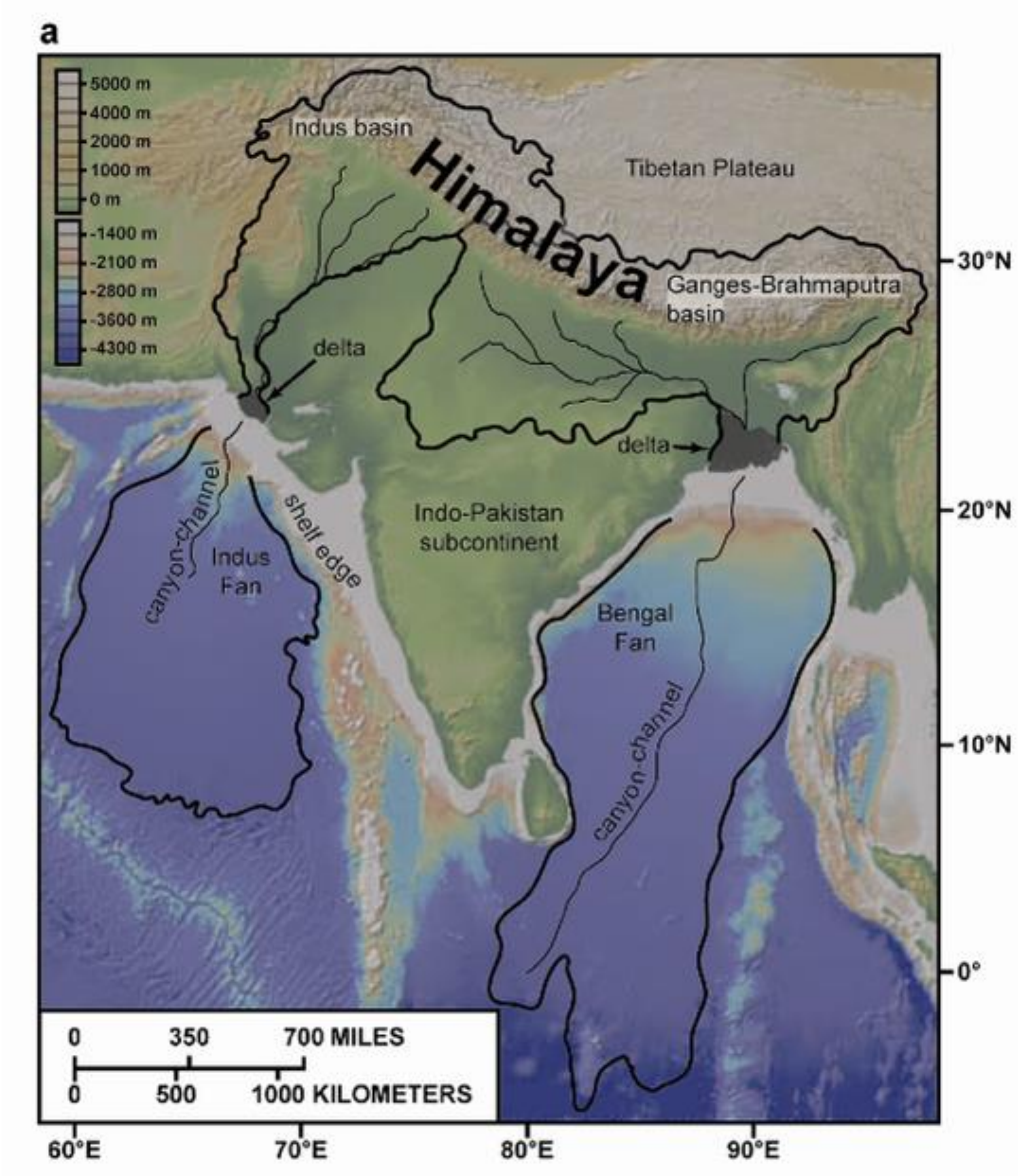
Pluri-lobi coalescenti



SIZE of deep sea fans

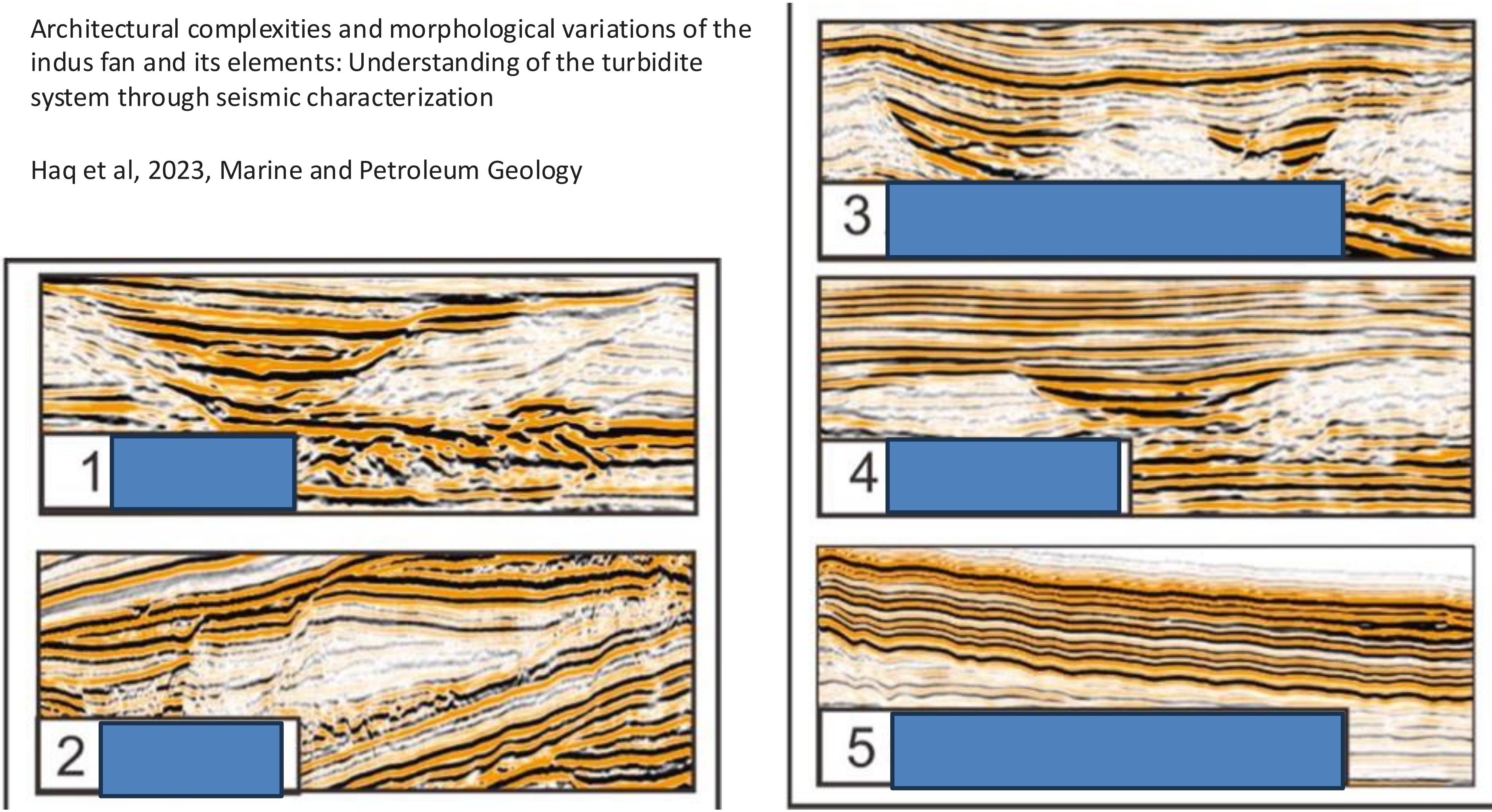


SIZE of deep sea fans



Architectural complexities and morphological variations of the indus fan and its elements: Understanding of the turbidite system through seismic characterization

Haq et al, 2023, Marine and Petroleum Geology



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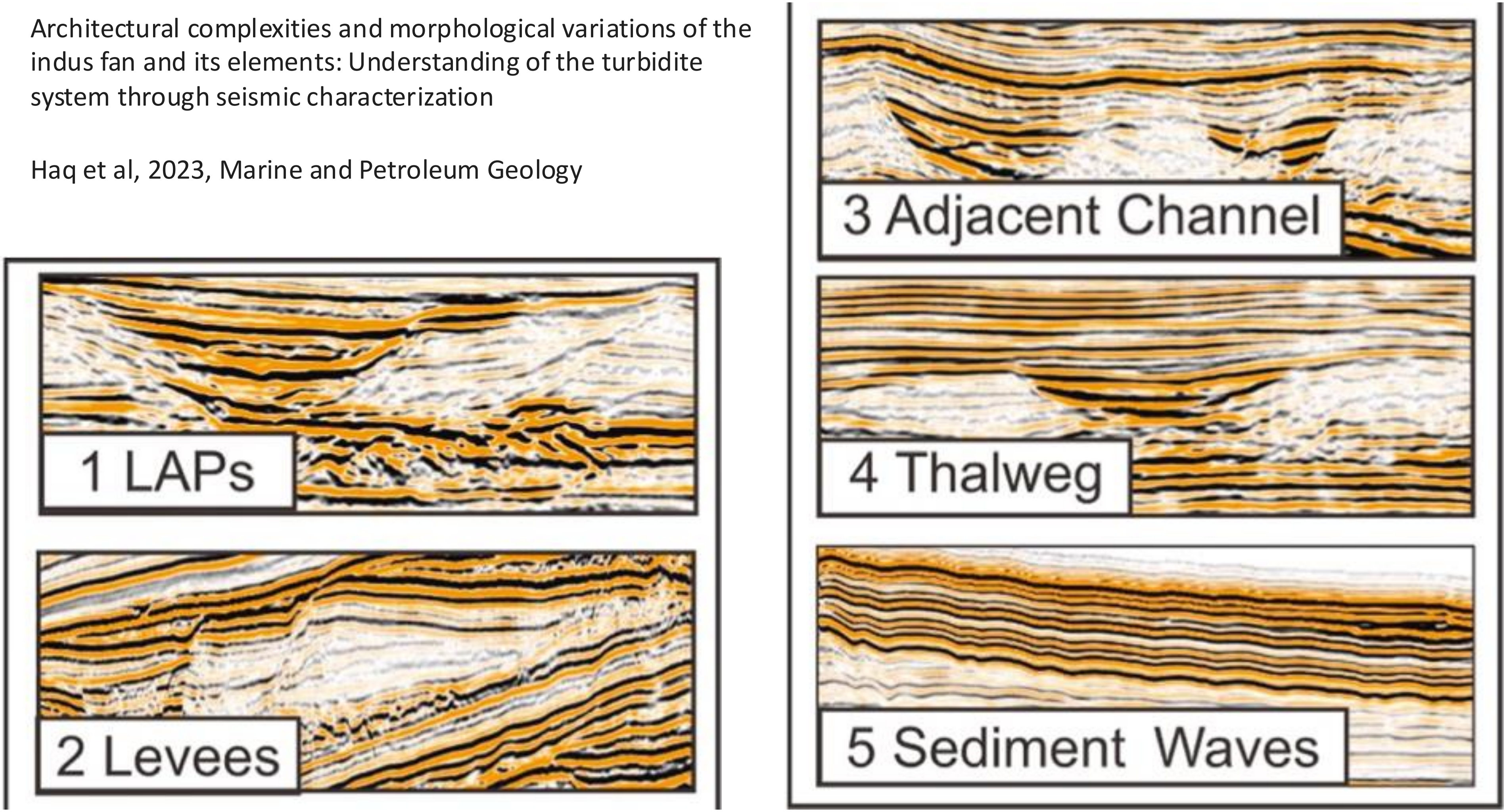

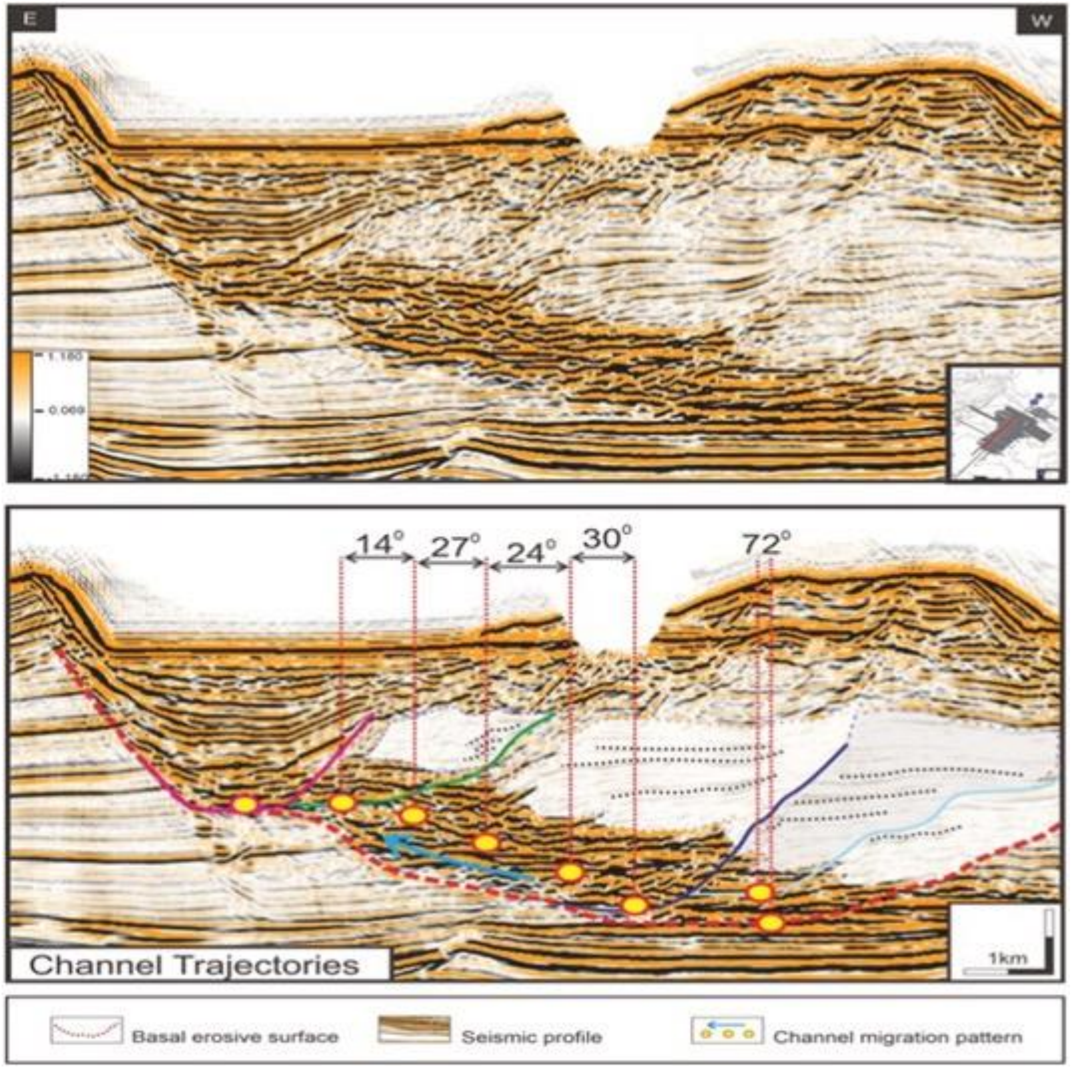
E
W
14°
27°
24°
30°
72°
Channel Trajectories
1km
Basal erosive surface
Seismic profile
Channel migration pattern

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