

High-Latitude Canyon Development and Associated Depositional Element Evolution; Southwest Grand Banks Upper Slope, Canada*

By

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Abstract

Analysis of sediment cores, 2D Huntect and 3D shallow seismic-reflection data reveal two main canyon types: 1.) those that have relatively broad, flat bottoms, which are probably formed by glacial outburst floods with inner terraces likely to be formed by proglacial failures. These canyons are principally erosional in their axes, their floors are dominated by winnowed conglomerates and stiff Pleistocene muds with terraces recording recent axis bypass; 2.) canyons that do not extend updip to the shelf margin but terminate locally and appear to be created by retrogressive failure (modifying aggradational deposits) and are draped by Holocene and Pleistocene muds. The shallow 3D data reveals upper slope accommodation space created by large-scale mass wasting events, reflecting a period of slope failure. These events are succeeded by a complex history of deposition dominated by smaller-scale mass transport deposits and canyon/channel overbank deposits. The slope failure and associated deposits fundamentally setup the canyon configuration that is observed on the modern seafloor. Two interrelated processes controlled canyon development: 1.) the failure scarps resulting from the mass wasting event created accommodation space available for canyon ridge aggradation and 2.) the scarps captured subsequent sediment gravity flows necessary for their construction. It is demonstrated that these scarps act as a precursor to canyon development. Large slide blocks (up to ~2 km³) created topography on the paleo-seafloor and were preferential sites for locally ponded deposition. The canyon ridges internally record a complex history of overall aggradation via sediment gravity flow deposits and degradation by erosive flows and slumping. Isopach maps and reflection geometries of individual packages indicate offset stacked overbank wedges in the construction of these ridges.

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Findings:

- Slope basin formed as a result of major failure
 - This sets up modern canyon configuration (seafloor)
 - Canyon locations are determined by the position of older slump scarps
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Two types of canyon on the slope:

1. Those that developed through ridge aggradation (connected to the shelf)
 - Canyon axes are predominantly non-depositional
 - Ridges record a complex evolution of aggradation and degradation
 - These may be composed of thick packages of very thinly-bedded turbidites

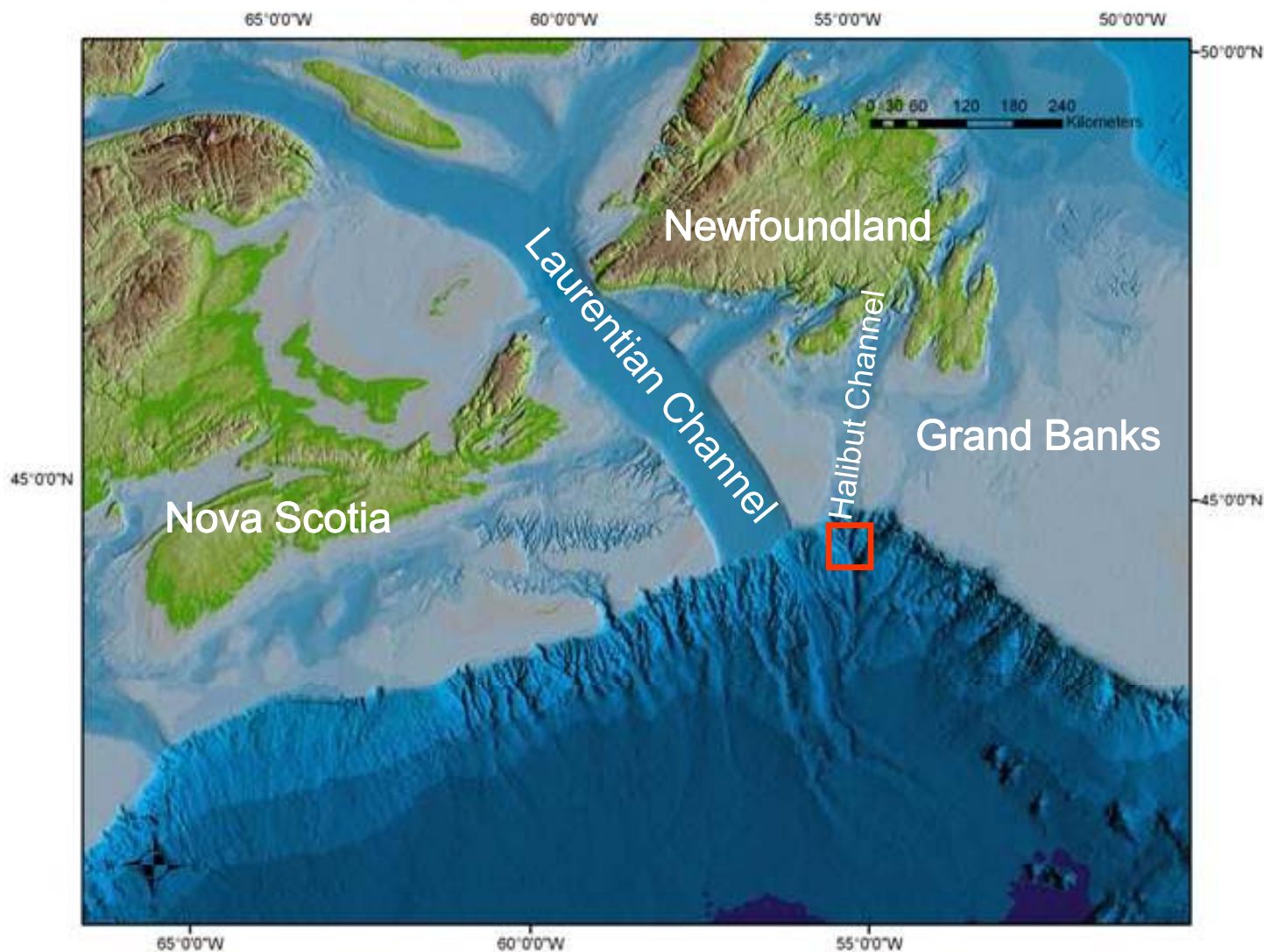
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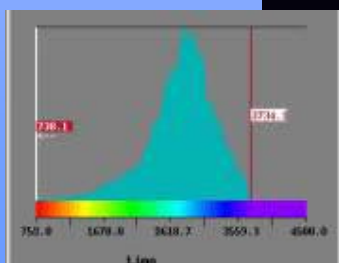
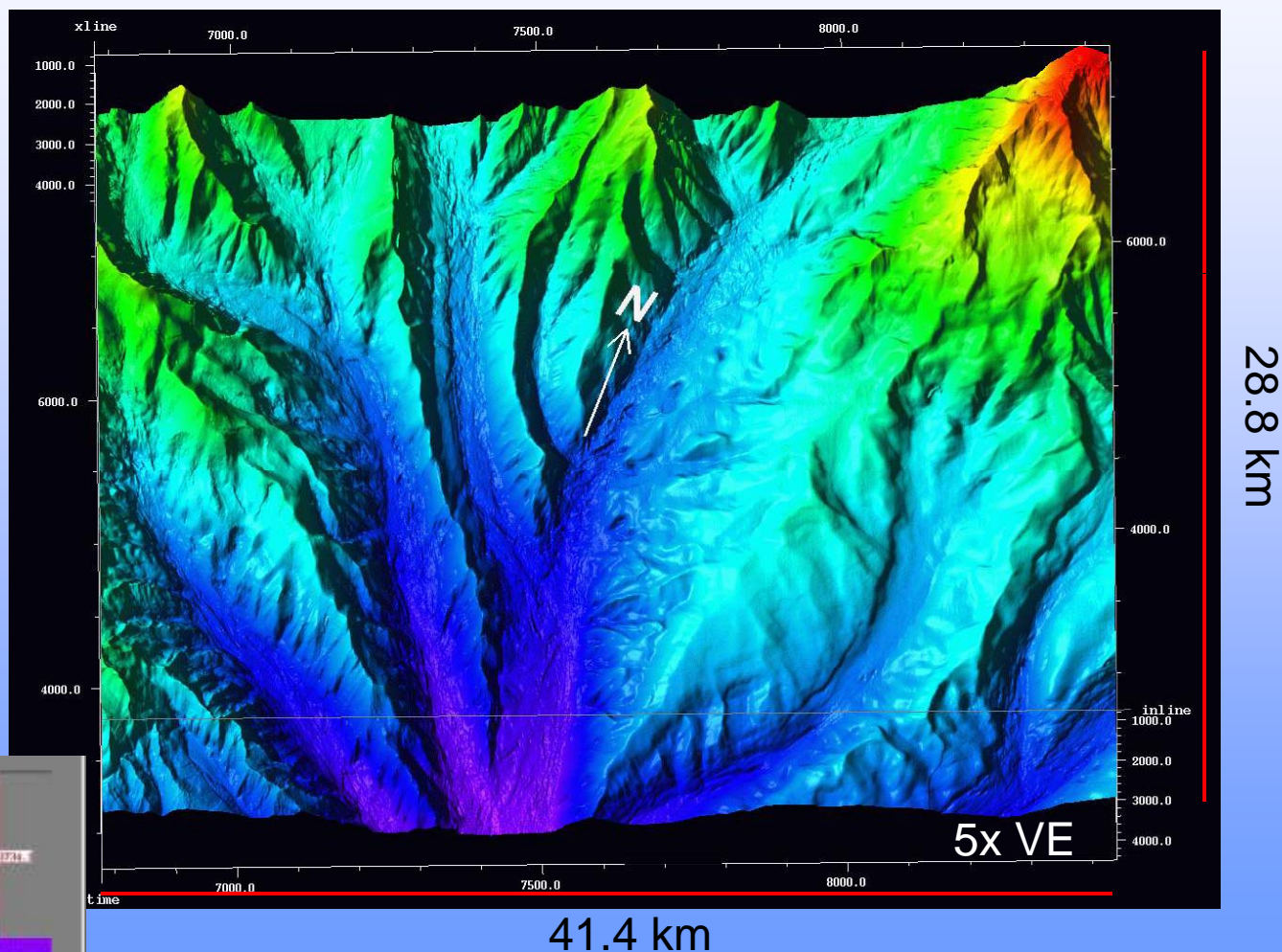
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 - Fill is predominantly overbank deposits from flows passing down surrounding canyons.

Location of the 3D volume, Southwest Grand Banks Slope

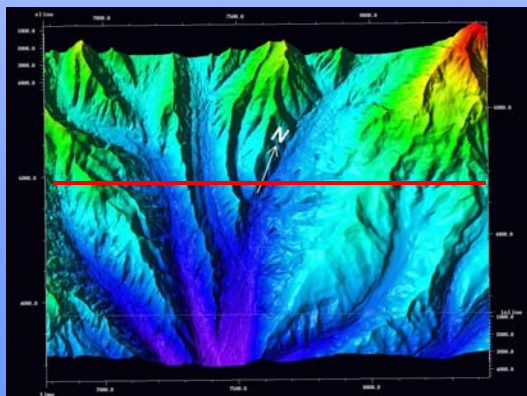
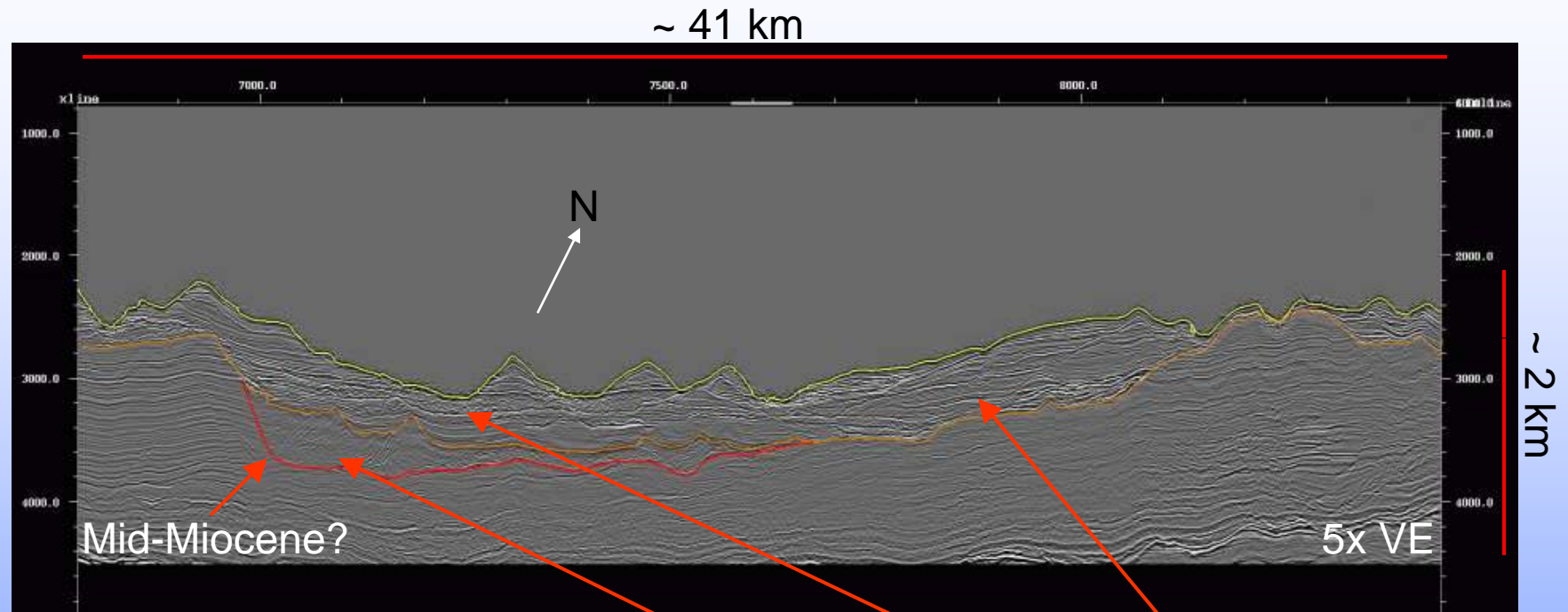


A time-structure (bathymetry) map of the seafloor

Depth below sea level is between ~ 400 m – 2000 m

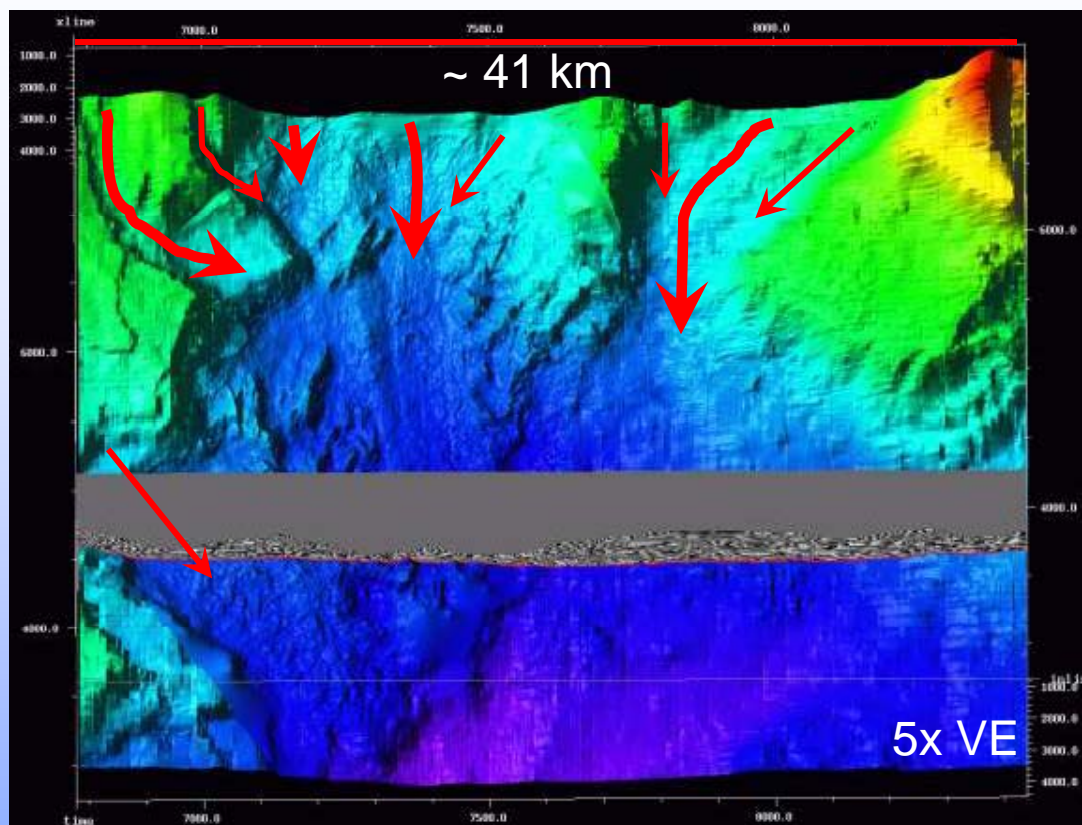


Basin-forming failure



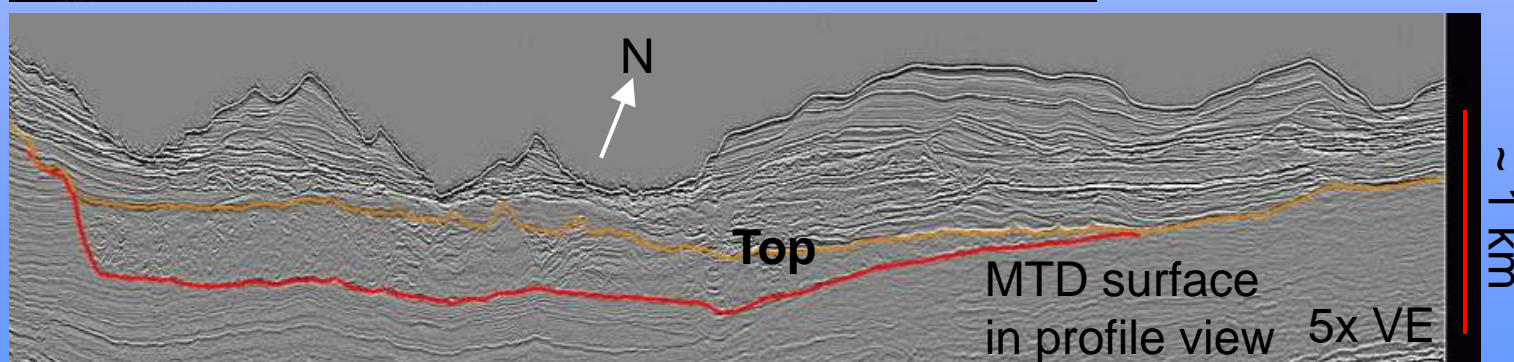
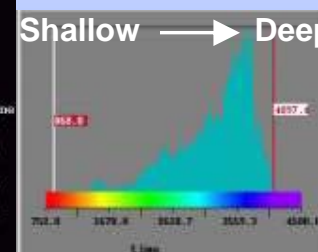
- A major failure episode – deposits can be traced across the volume
- Proceeded by high-amplitude, depositionally complex packages

Time-structure map: Top of mass transport deposits (MTDs)

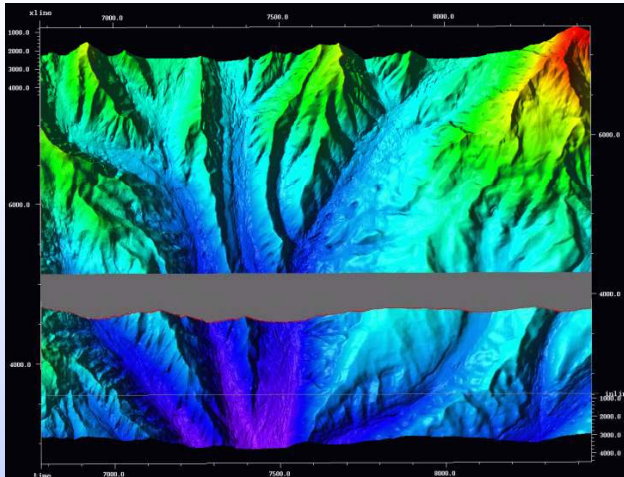


Top of MTDs:

- The failure scarps and associated deposits set up modern slope configuration
- Arrows highlight scarps (commonly scoop shaped) on the top of the MTDs

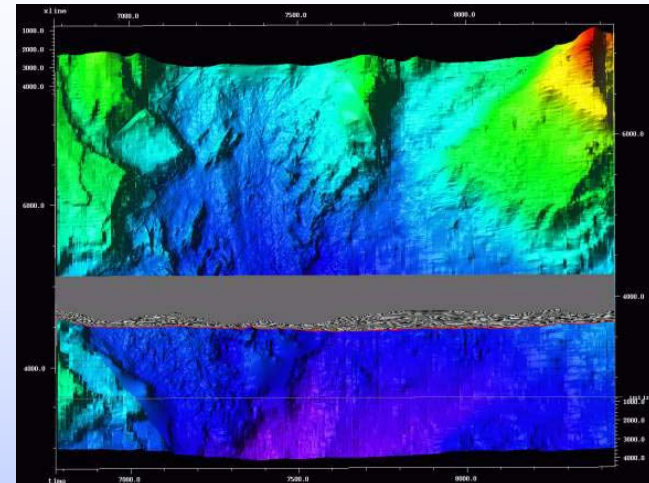


Seafloor time-structure map draped as an attribute over the 3D MTD surface



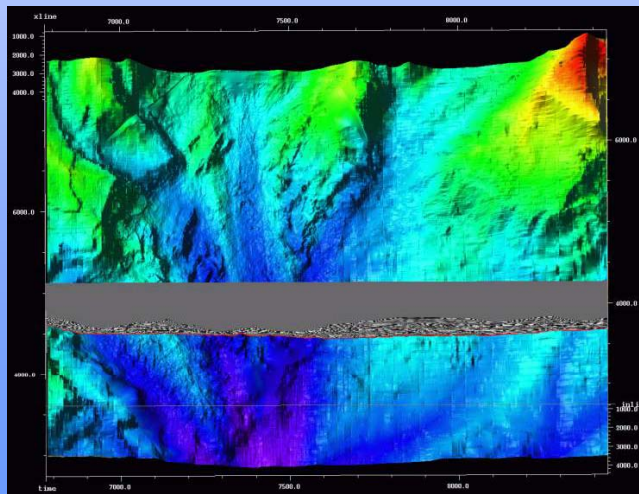
Time-structure map of seafloor
(draped on seafloor)

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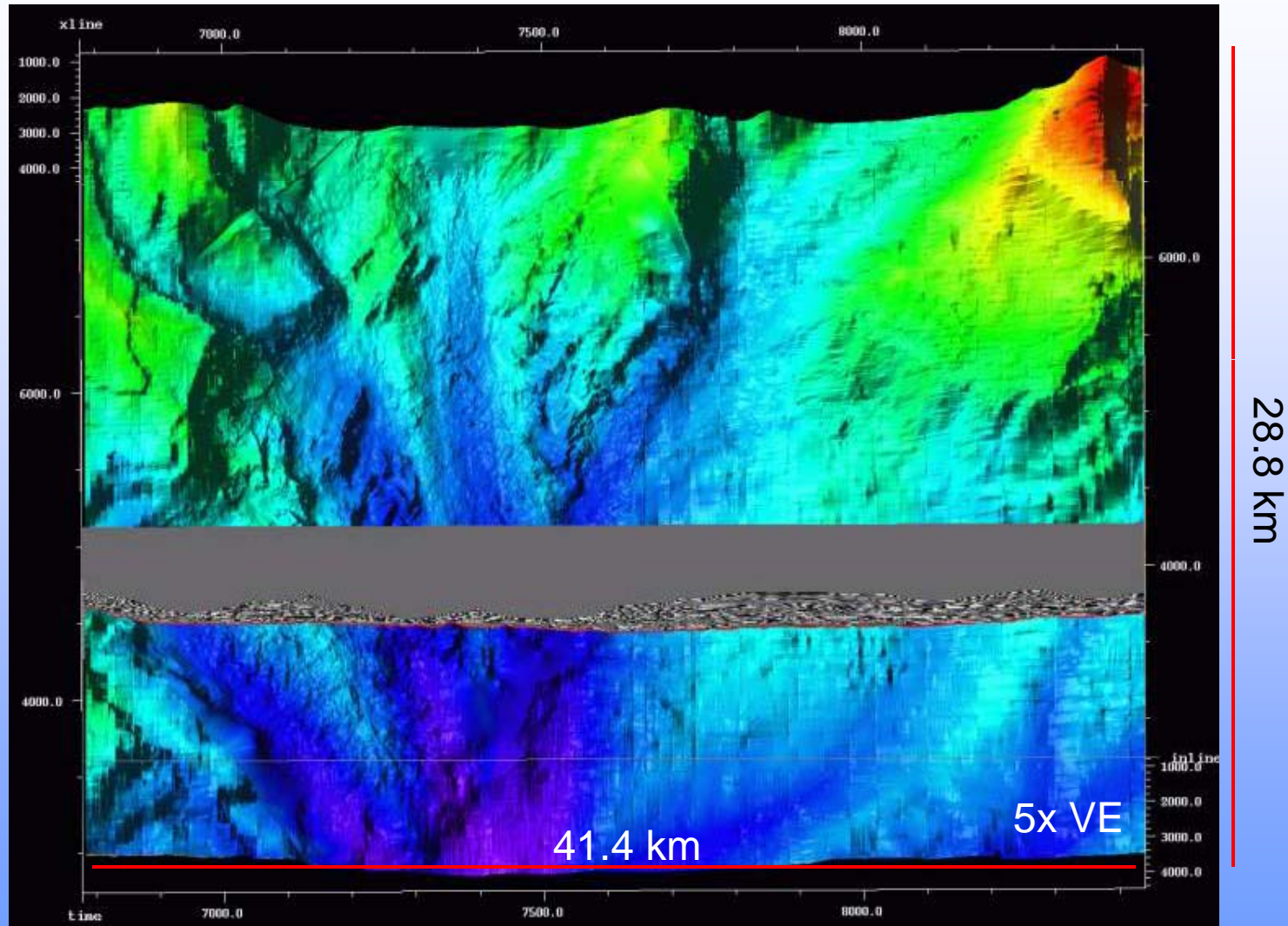
Time-structure map of MTD surface
(draped on MTD surface)

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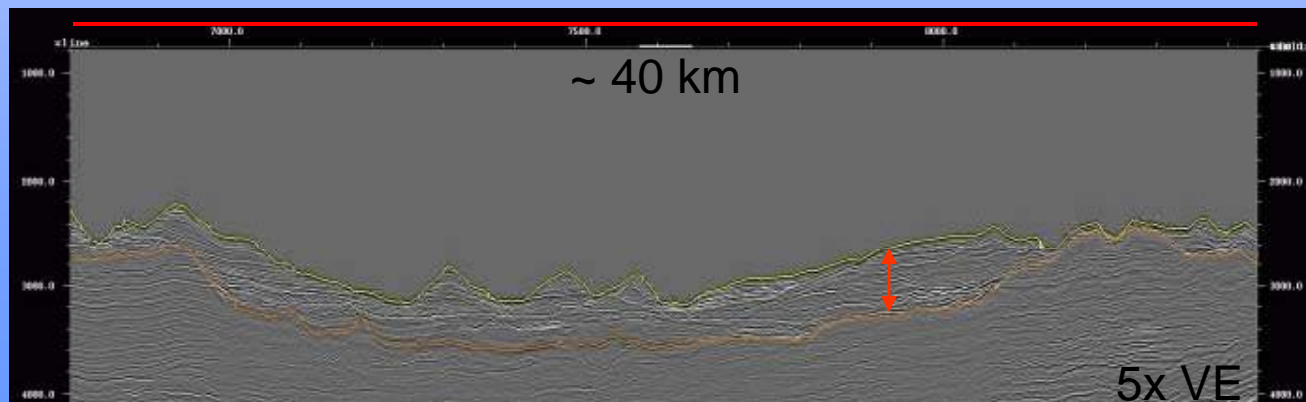
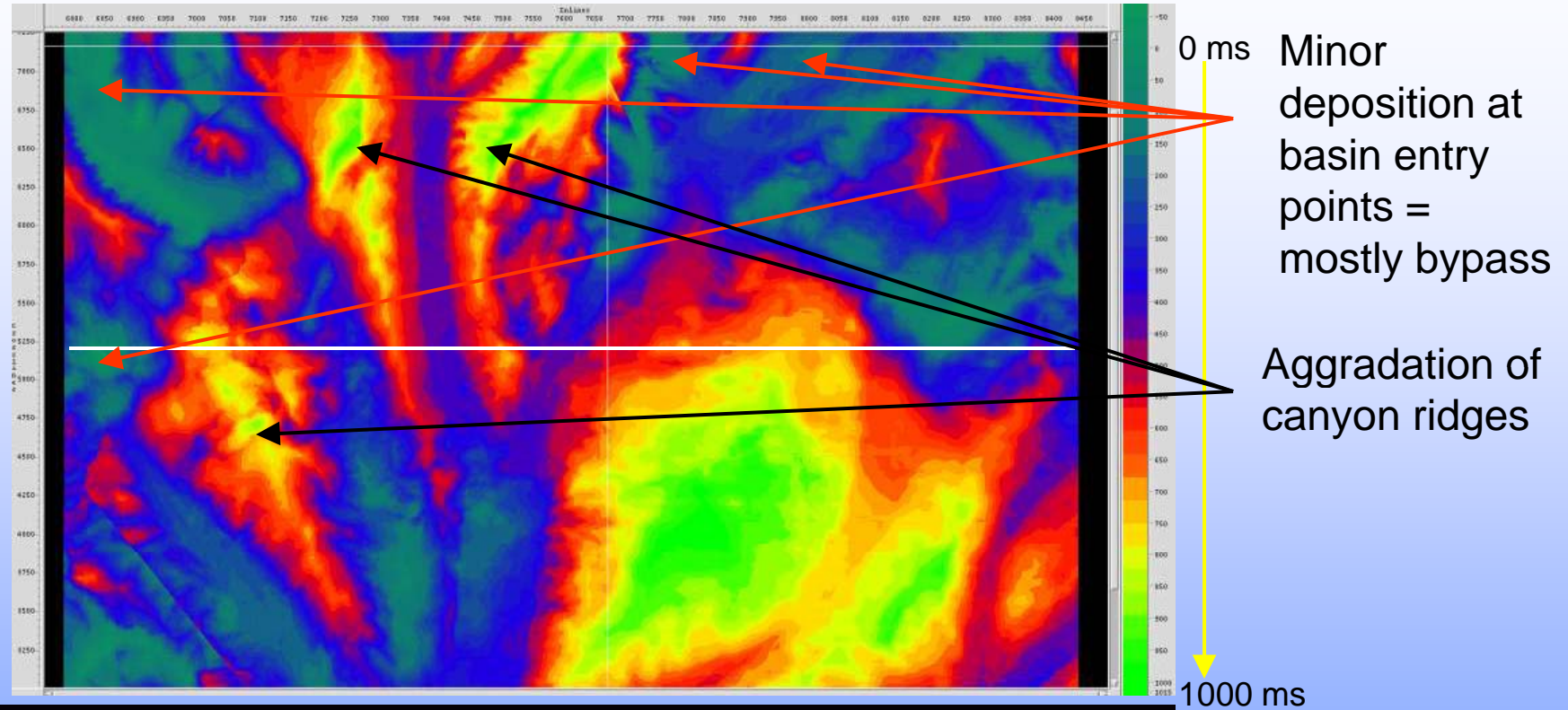
Seafloor time-structure attribute
draped over the MTD surface

Seafloor time-structure attribute draped over the MTD surface



Similarity between the seafloor morphology and the paleo-morphology related to the MTD surface

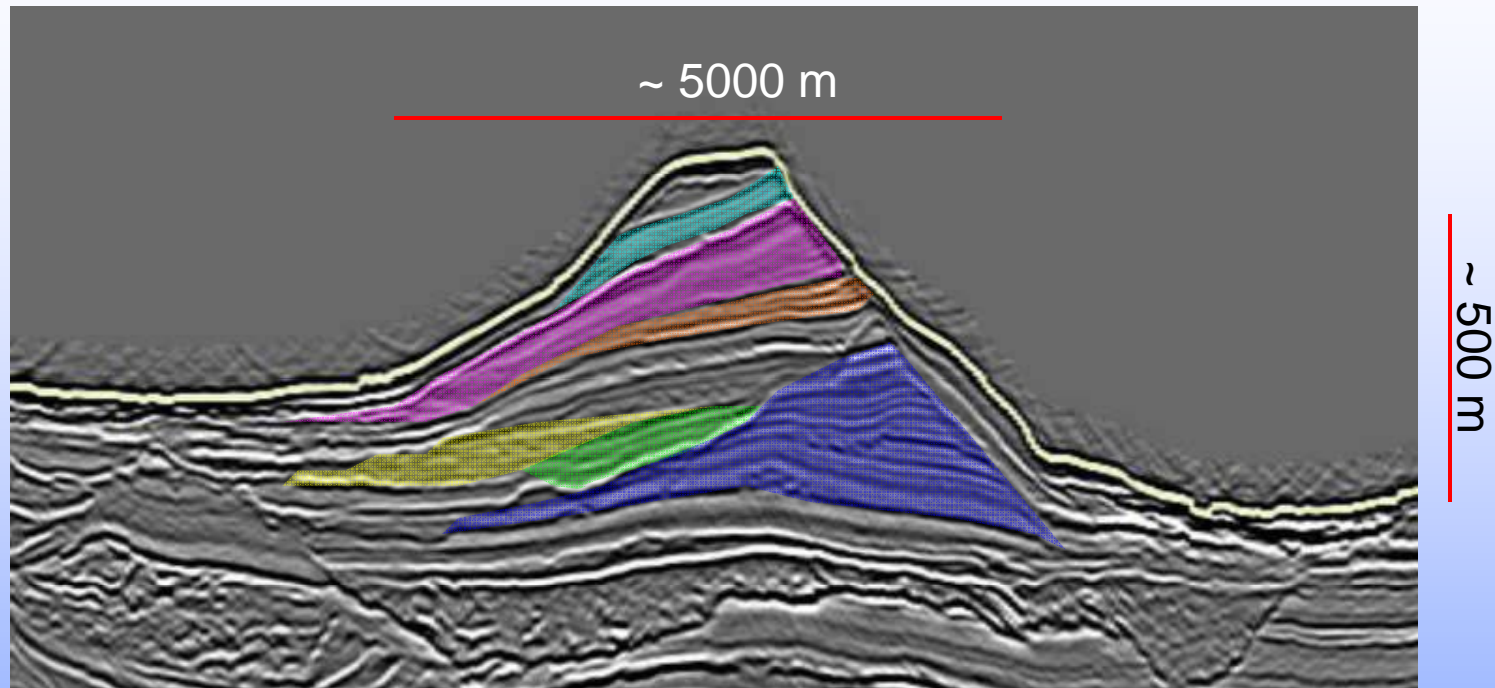
Isochron map of the interval between MTD top surface and seafloor



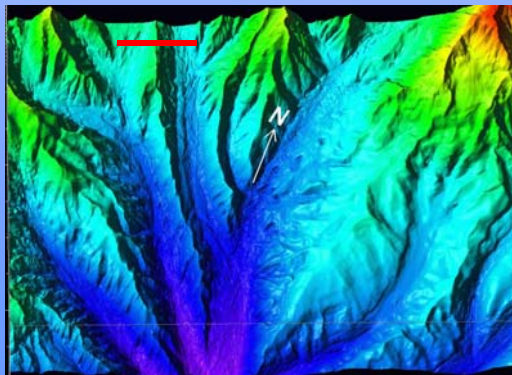
Interval between seafloor and MTD surface

Canyon Evolution - Grand Banks

Internal Ridge Growth

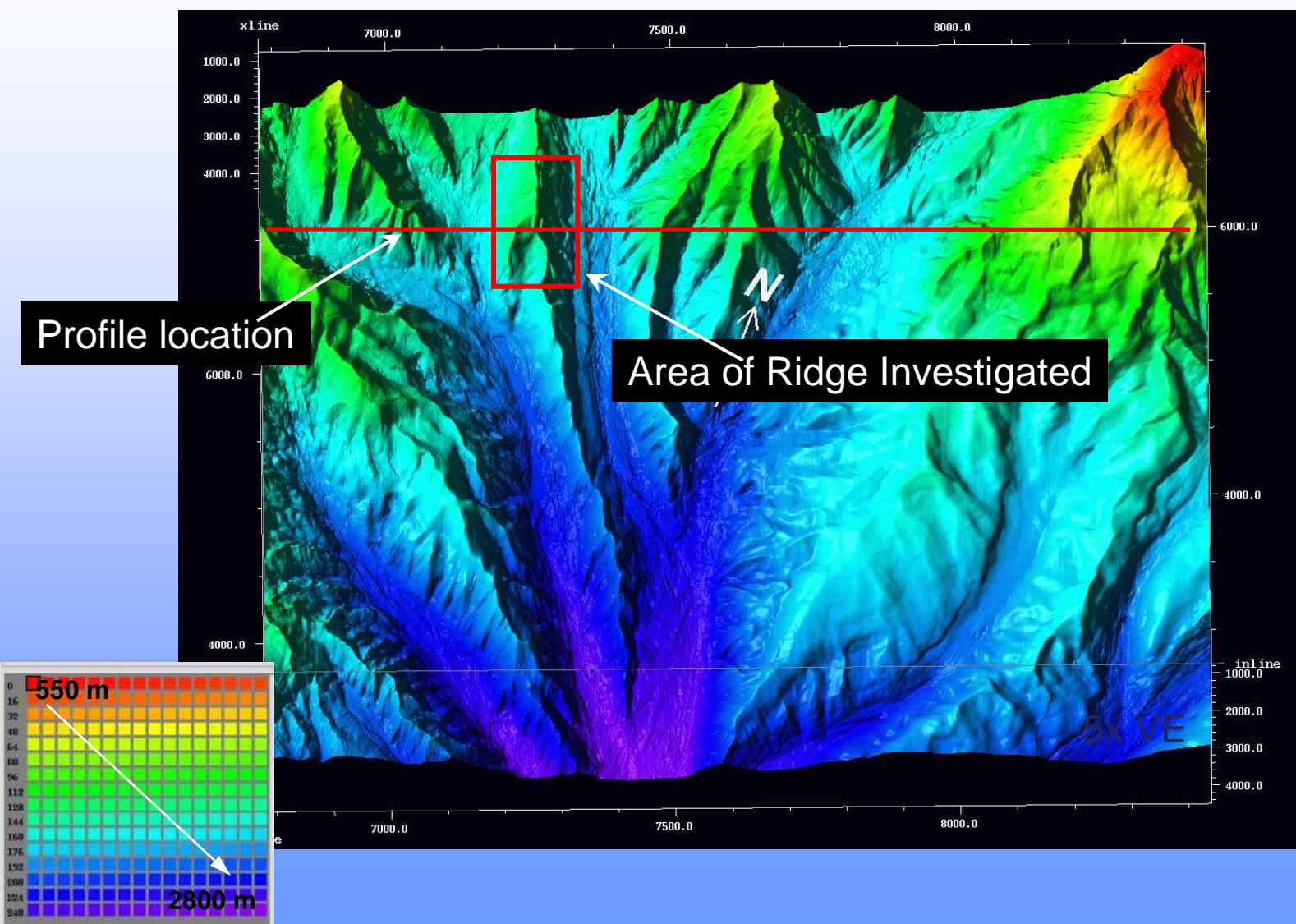


Profile location



- Canyon ridges evolve partly through aggradation (and subsequent erosion) of wedging packages
- Most of the turbiditic packages are offset as a result of different canyons active at different times

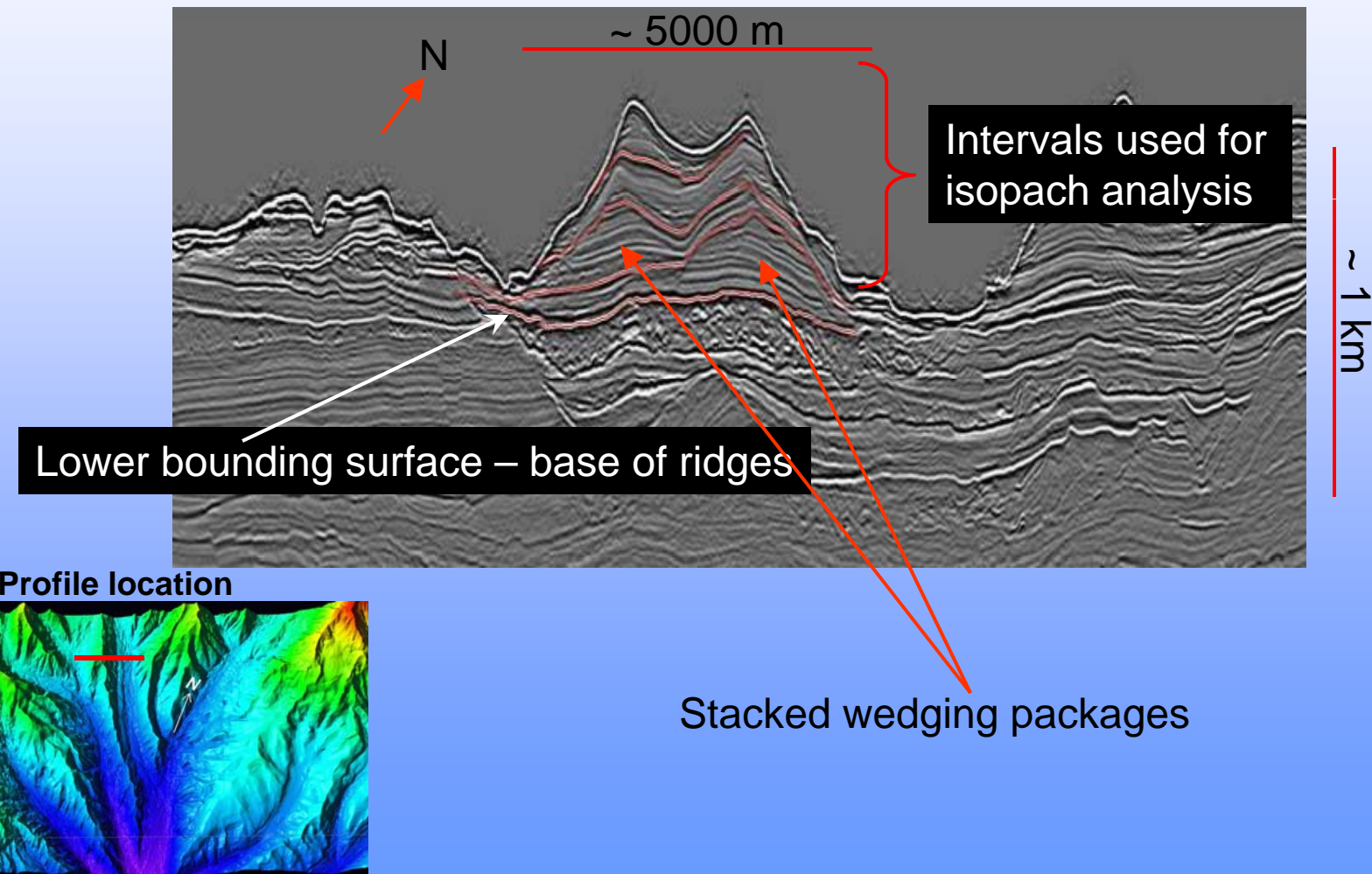
Evolution of aggrading ridges



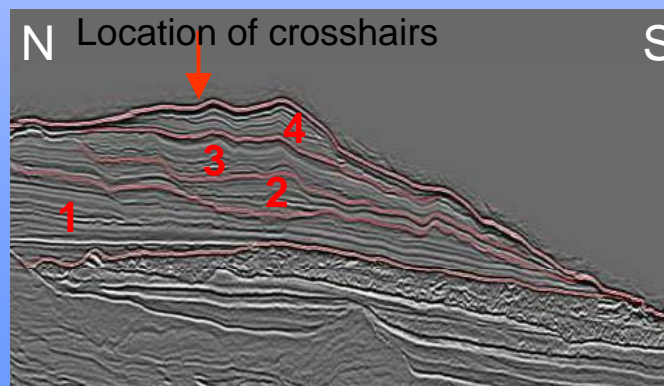
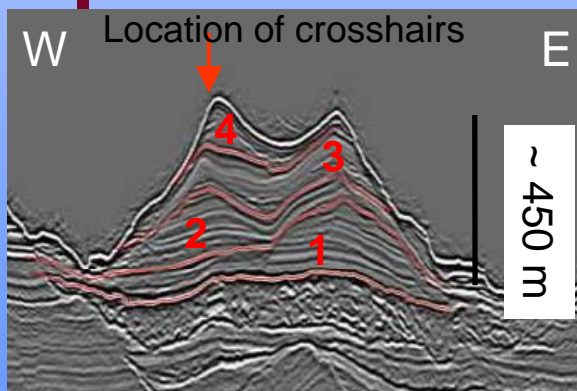
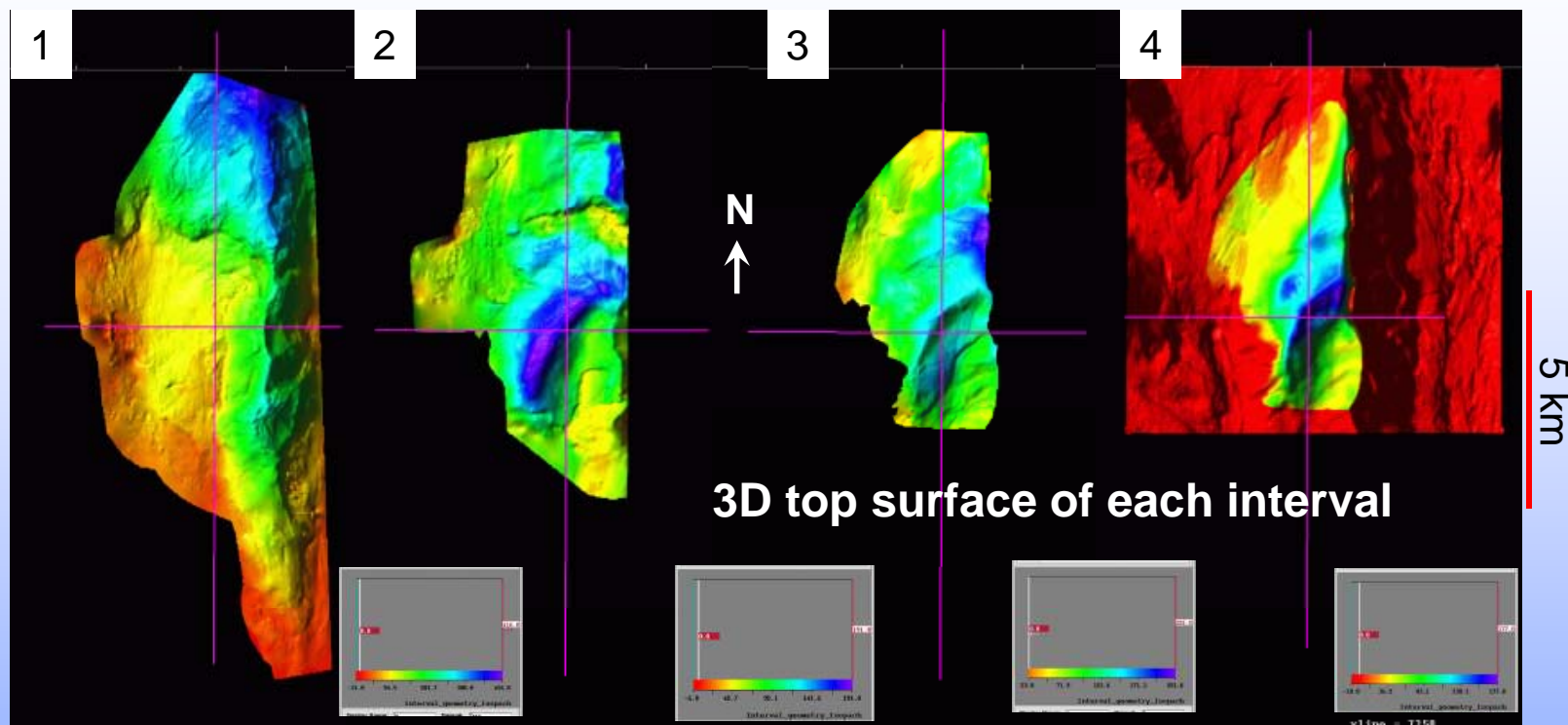
Canyon Evolution - Grand Banks

Ridge Isopachs

Horizons defining the four intervals between the seafloor and the lower bounding surface (the base of the ridges) used to investigate ridge evolution.



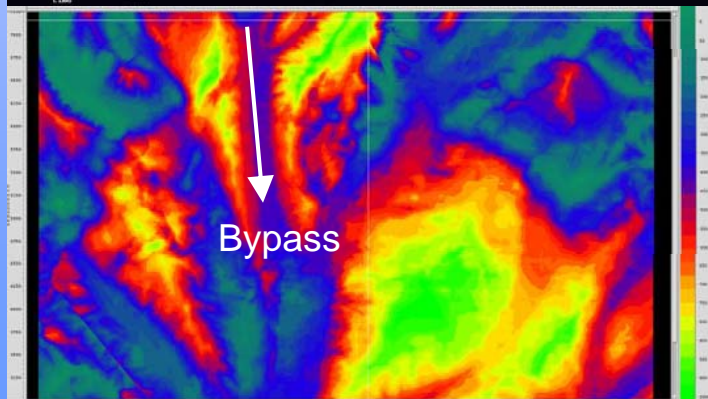
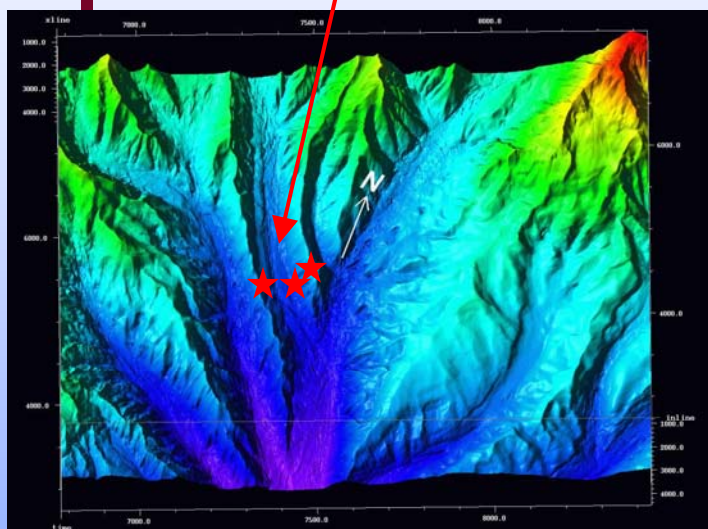
Composite of ridge isochron maps



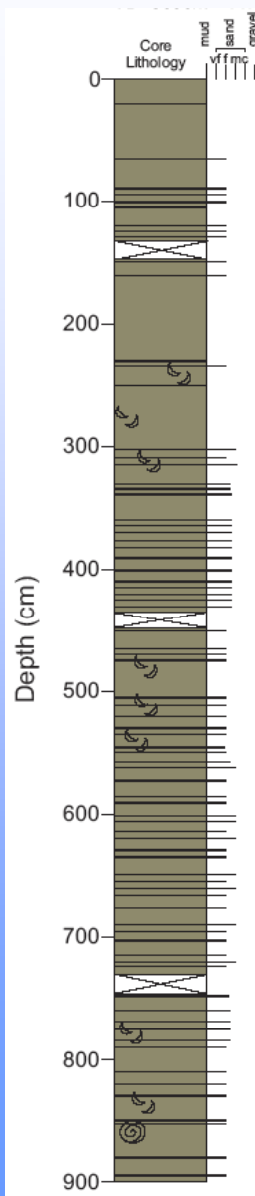
- Interval isochron attribute mapped to this surface
- This shows individual stages of ridge aggradation (deposition) vs. degradation (e.g. slumping/erosion)

Evidence For Recent Bypass?

Transect of sediment cores across the central canyon



Canyon Evolution - Grand Banks

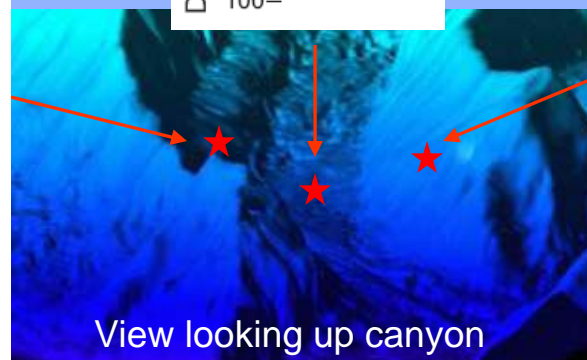
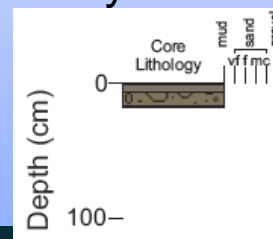


100 m above axis

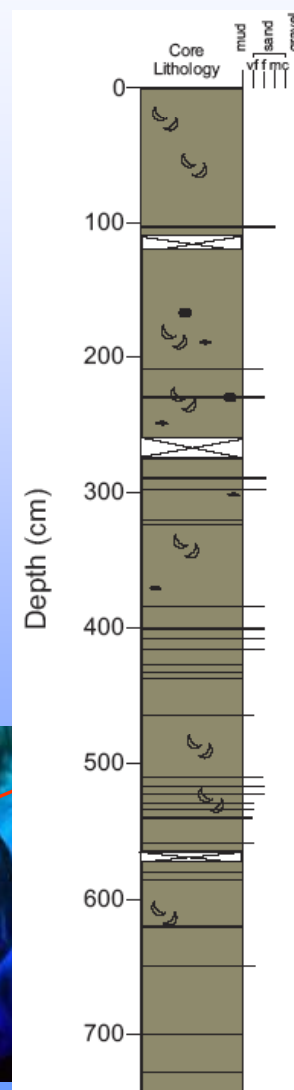
Holocene mud and thin turbidites on levees.

Pleistocene mud and winnowed cobbles on canyon floor

Canyon Floor



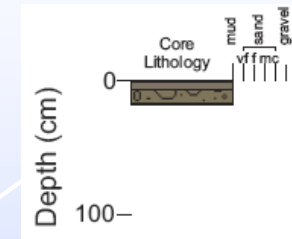
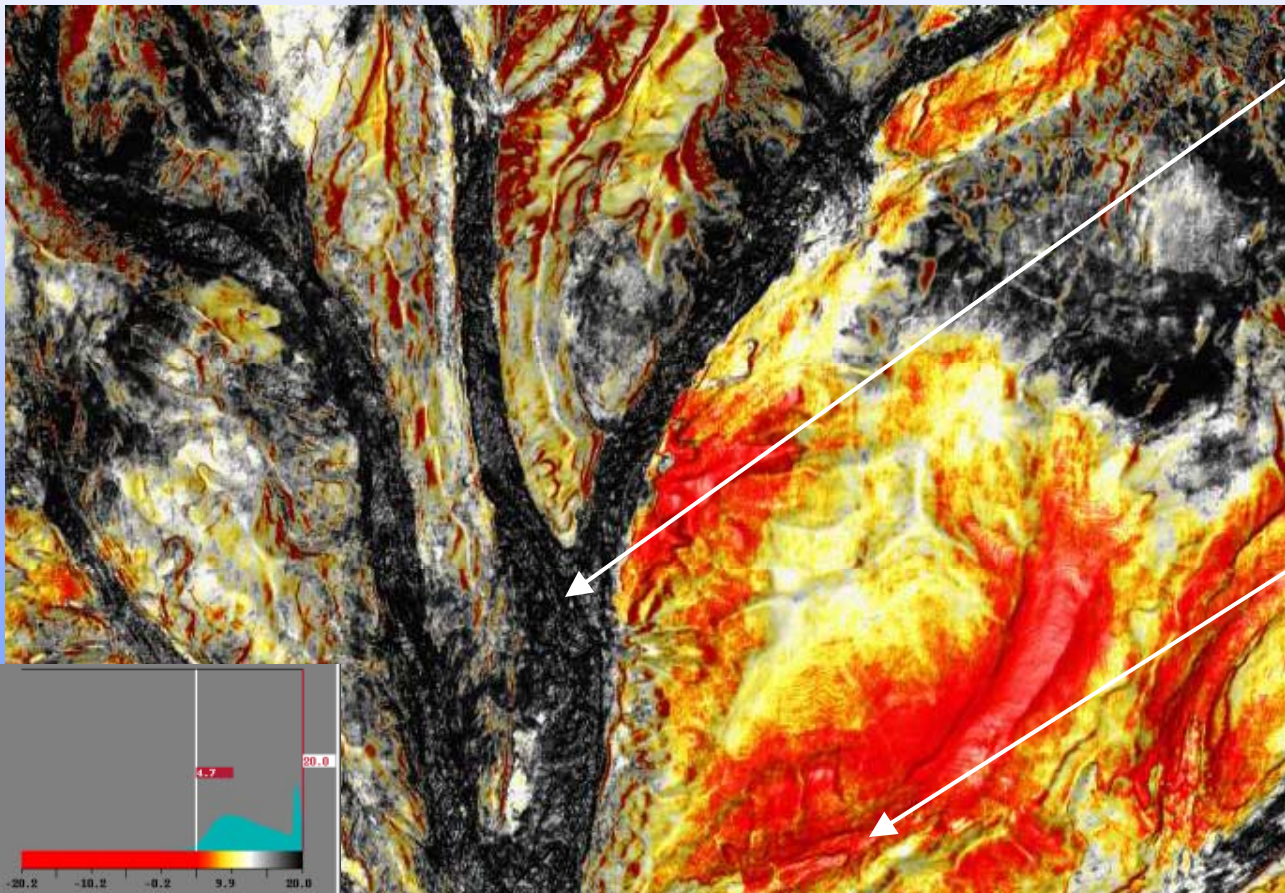
View looking up canyon



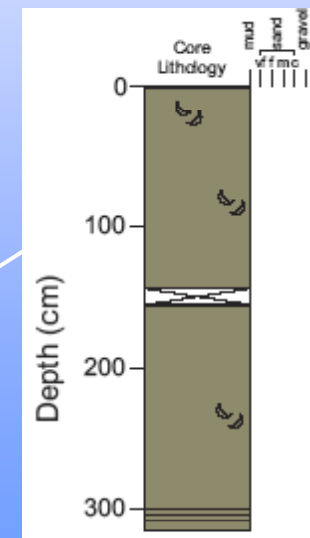
Seafloor Amplitudes

Very different amplitudes observed in the canyon types:

On the seafloor this is due to the lithology in their axes

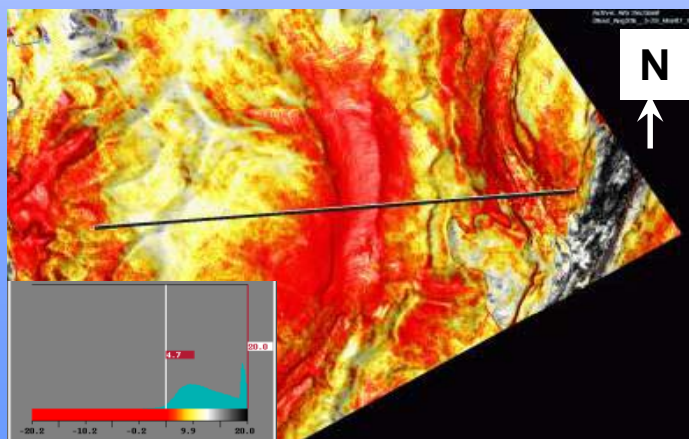
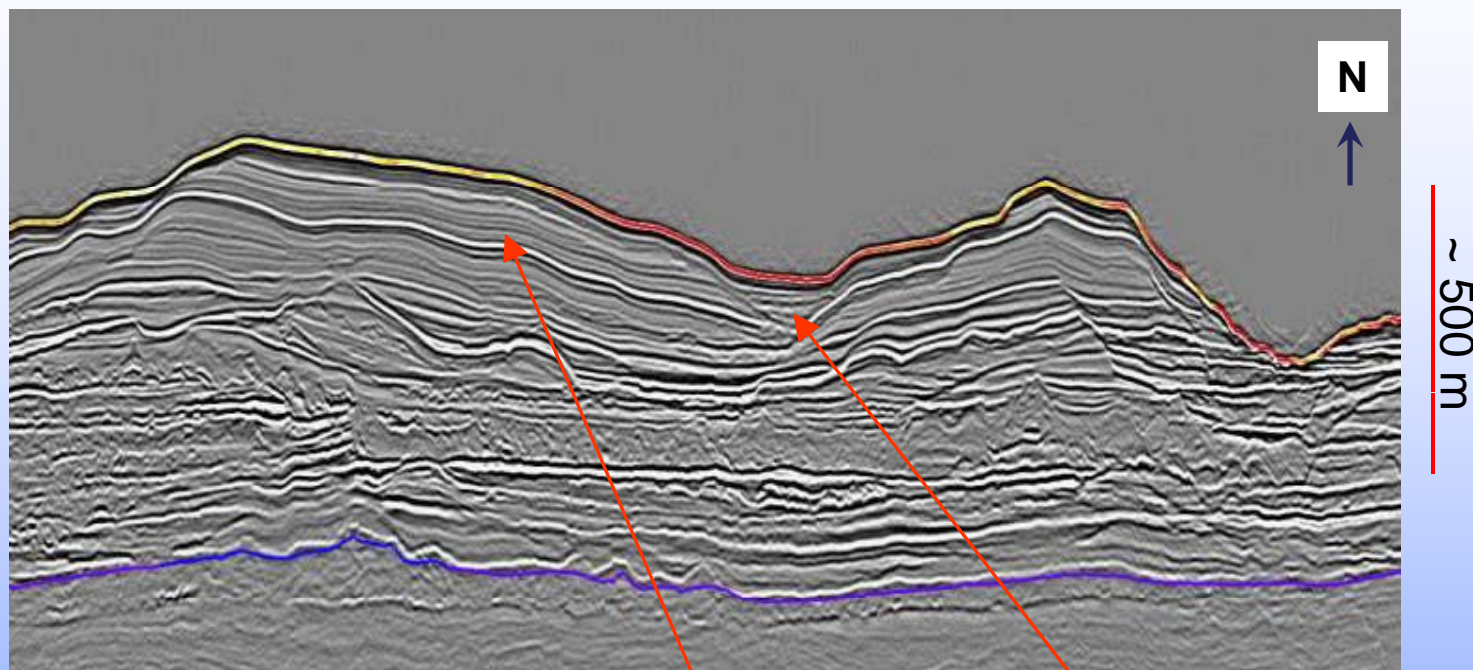


Winnowed cobbles
and Pleistocene
mud



Holocene
mud drape

Eastern Canyon

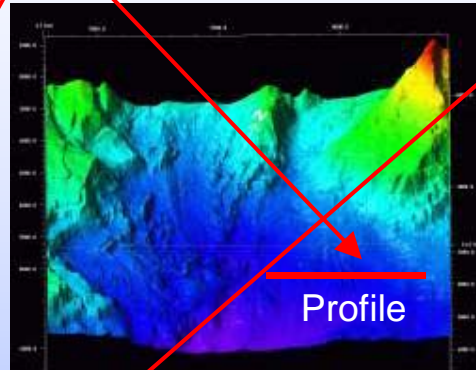
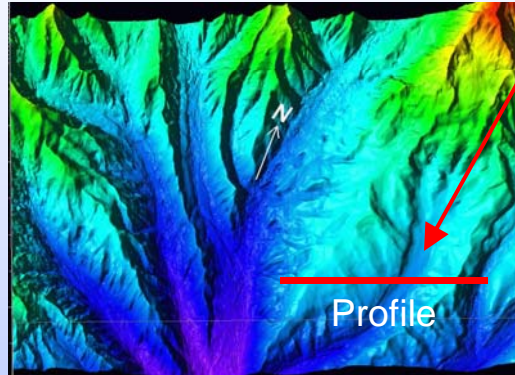


Aggrading canyon axis

Aggrading canyon ridges, internally
not dominated by slumping

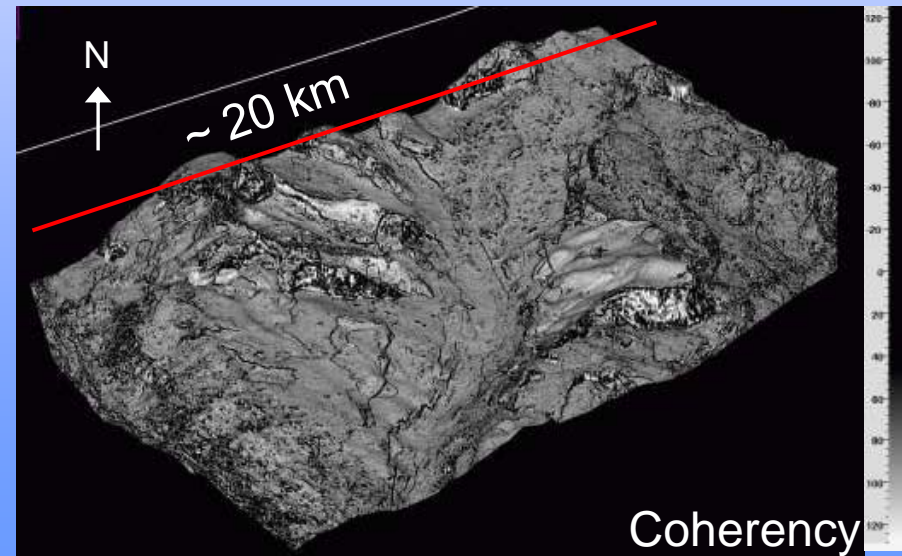
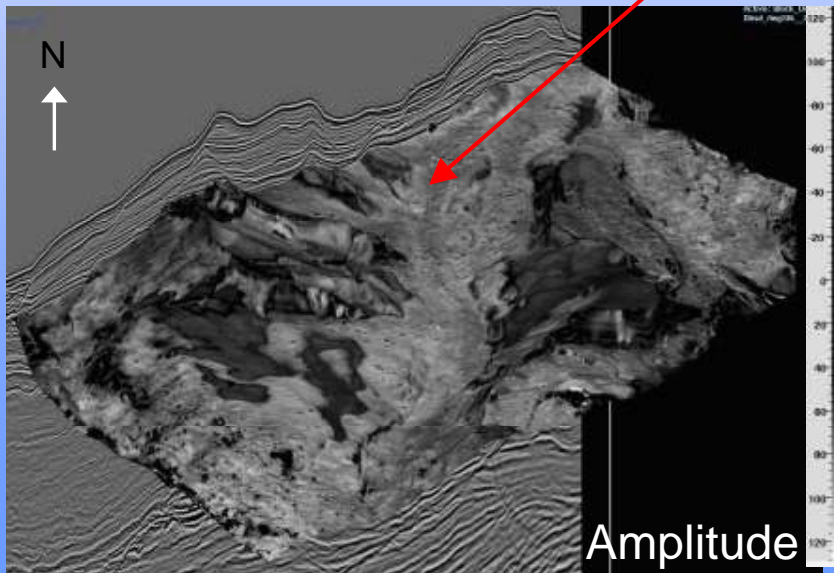
Eastern Canyon

This canyon is observed on the seafloor, but on the MTD surface there is no evidence for its location



First evidence of this canyon. Rafted blocks on canyon floor

Interpreted to be formed by retrogressive slumping of local 'ridge'



Conclusions:

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