Outcrop Example of Intrastratal Slope Deformation Controlled by Depositional Architecture, Tres Pasos Formation, Magallanes Basin, Chile*

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Abstract

Sediments deposited on slopes have been shown to deform in a dominantly down-slope direction driven by the force of gravity after deposition and burial. Multidirectional gravitational spreading and contemporaneous deformation can occur over a broad range of timescales and depths from shallow-subsurface intrastratal faulting and folding to complete remobilization of material at the seafloor. Submarine slope deformation and failure has important implications for various aspects of petroleum exploration and development including: 1) evaluating potential hazards for seafloor infrastructure, 2) reservoir characterization and prediction in slope strata, and 3) interpretation of discontinuous or chaotic seismic facies associated with slope deformation. While instances of intrastratal slope deformation (e.g. creep or slip) have been documented at the microscopic and seismic scales there is a paucity of examples at the scale of centimeters to 10's of meters (reservoir scales). We present an outcrop example of syndepositional to synburial intrastratal slope deformation controlled by the distribution of turbidite deposits. Deep-marine slope deposits of the Cretaceous Tres Pasos Formation in the Magallanes Basin are exceptionally well exposed along a 3.5 km transect of the Rio Zamora at Cerro Mirador in southern Chile. Facies include: 1) thick-bedded sandstone facies (TSF; 25–200 cm beds), 2) thinly interbedded sandstone and mudstone facies (SMF; 5–30 cm beds), and 3) mudstone-prone facies (MPF; 1–10 cm beds). Facies transition significantly at the meter scale both laterally and vertically due to relative position within a composite succession of compensationally stacked, low aspect ratio sandstone-dominated bodies. Localized zones of cm- to m-scale faulting and subsidiary rotation and folding of discrete beds are bracketed by undeformed intervals that are present dominantly

in SMF facies. Fault and fracture planes are parallel to downslope paleoflow orientation. The resulting interpretation is downslope creep deformation with localized slip planes (décollements) in fine-grained interbeds of MPF. The distribution of SMF and/or MPF is interpreted to be a key control on the locations of slip and associated deformation. These results highlight important dynamics and feedbacks in slope environments between depositional architecture, intrastratal deformation, and seafloor topography.

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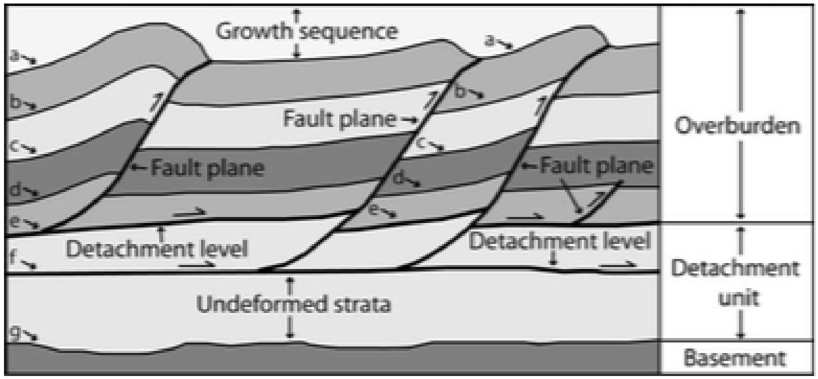
Importance of Meso-Scale Gravitational Deformation

- Previous examples of gravitational deformation
  - 'Typical' deep-water fold-thrust belt overlying a slip plane
  - Seismic example of slip plane and gravitational deformation
  - Stratigraphic architecture controls on gravitational deformation
- Basin overview and stratigraphic framework
  - architectural elements
  - regional geometries
  - influence of mass transport deposits (MTDs)
- Intrastratal deformation: outcrop examples and interpretations
- Implications and questions to consider

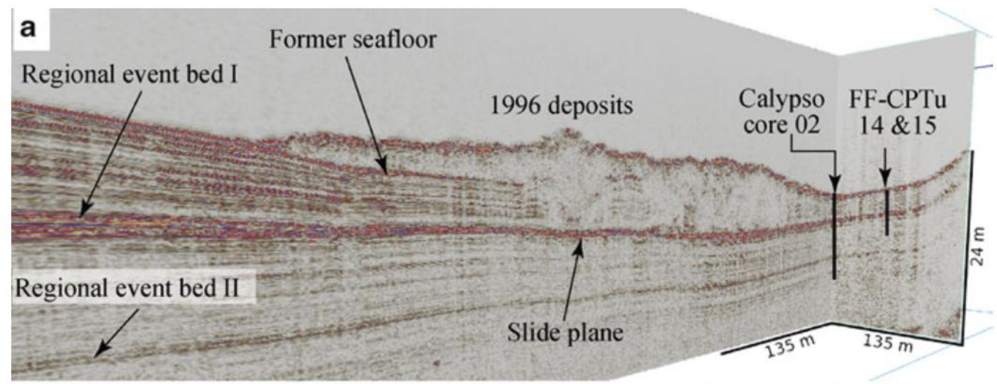
Seismic-Scale Examples of Gravitational Deformation

Typical Deep-Water Fold-Thrust Belt



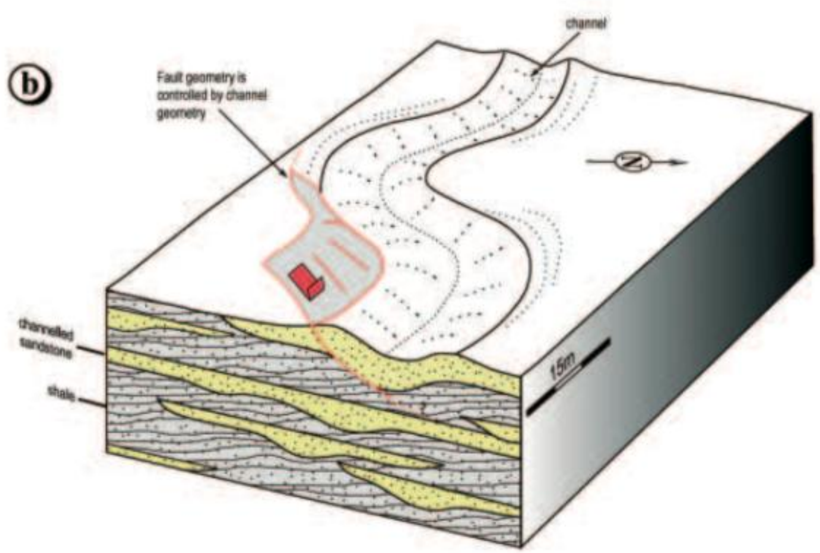
Maloney et al., (2010); *AAPG Bulletin*

Seismic-Scale Slip Planes

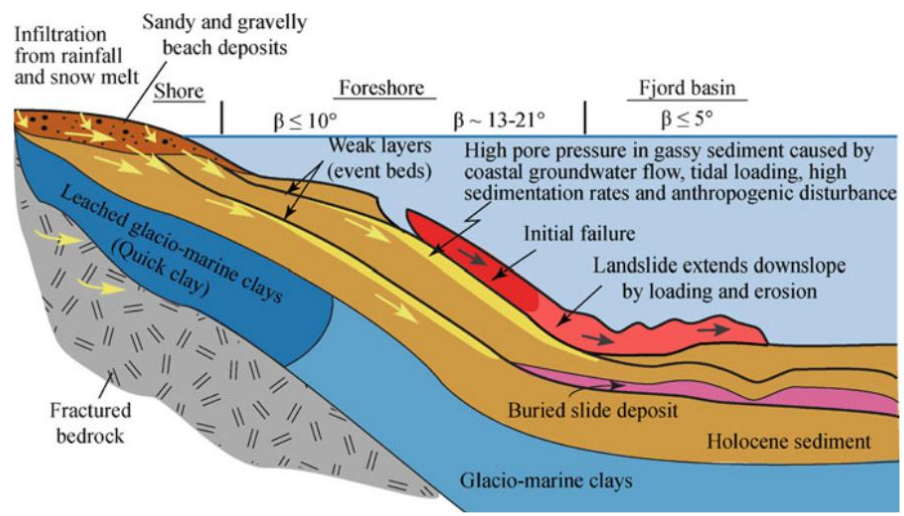


L'Heureux et al., (2012)

Stratigraphic Architecture Influence on Gravitational Deformation

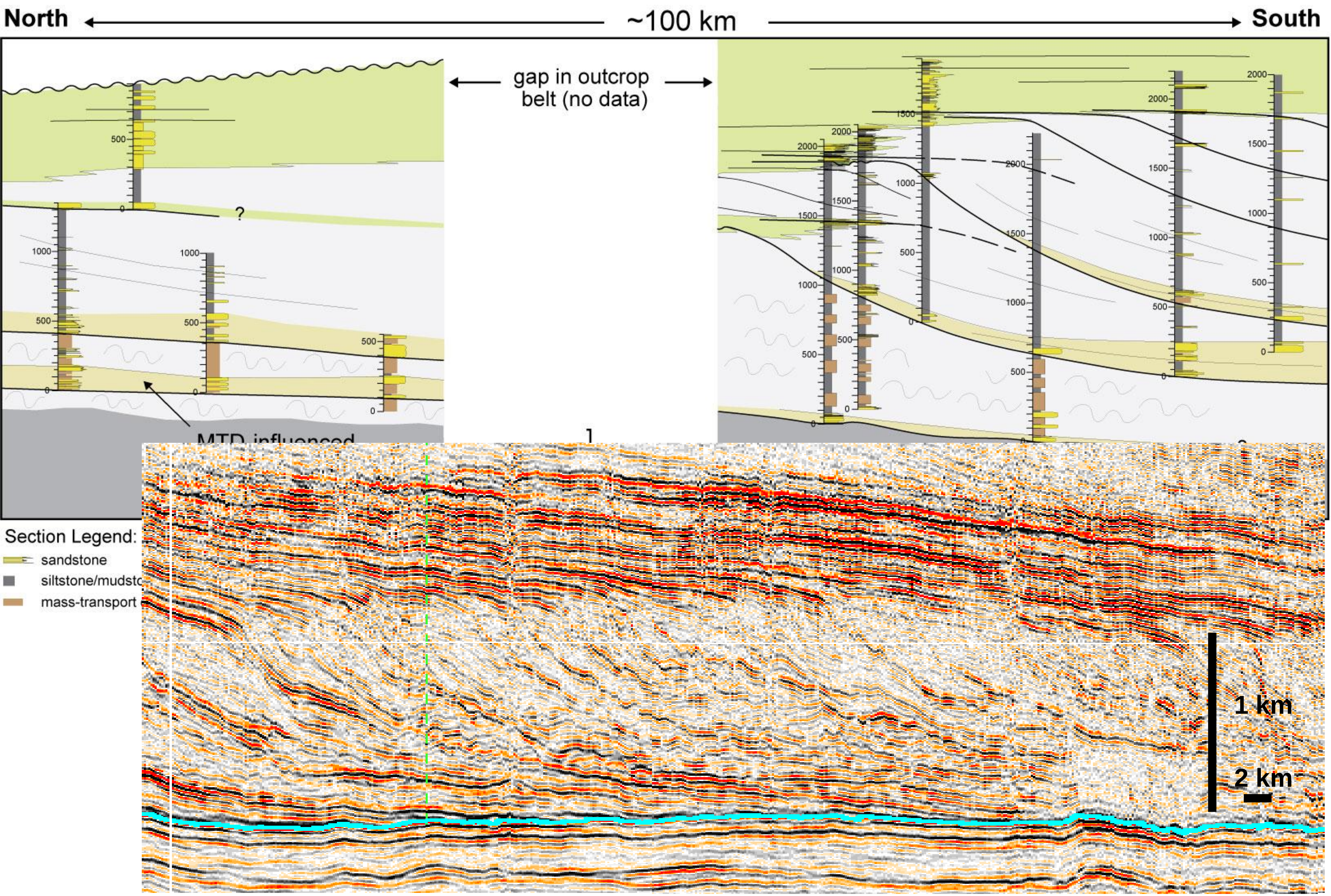


Moretti et al., (2003); *Petroleum Geoscience*

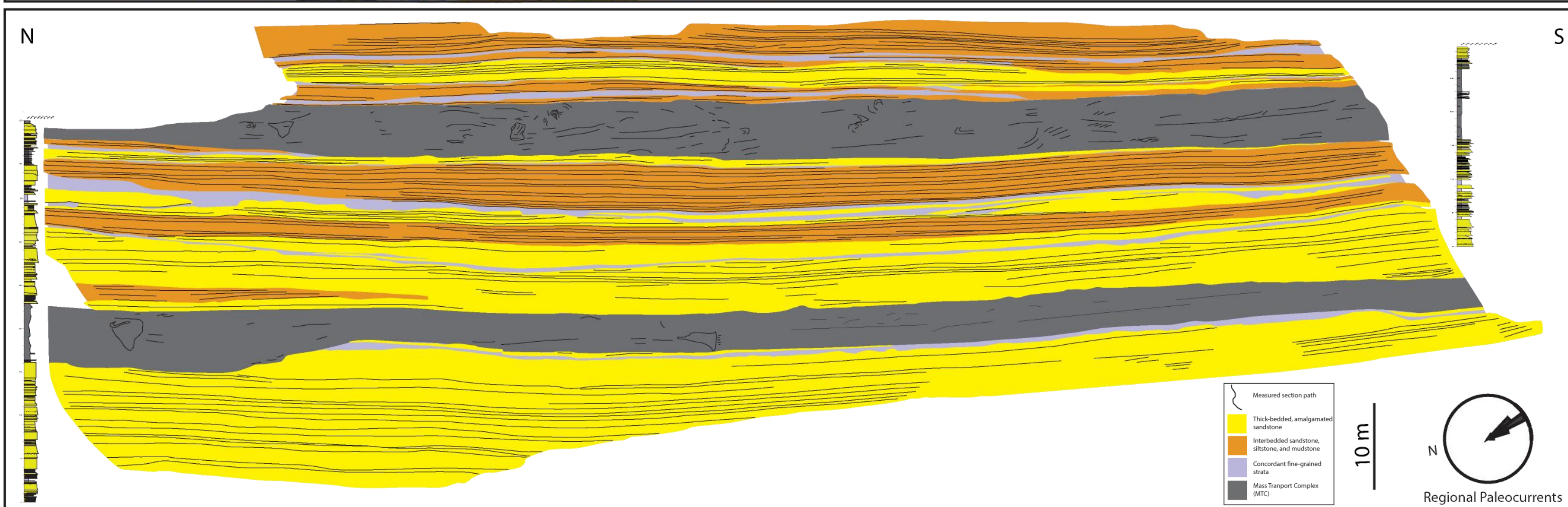


L'Heureux et al., (2012)

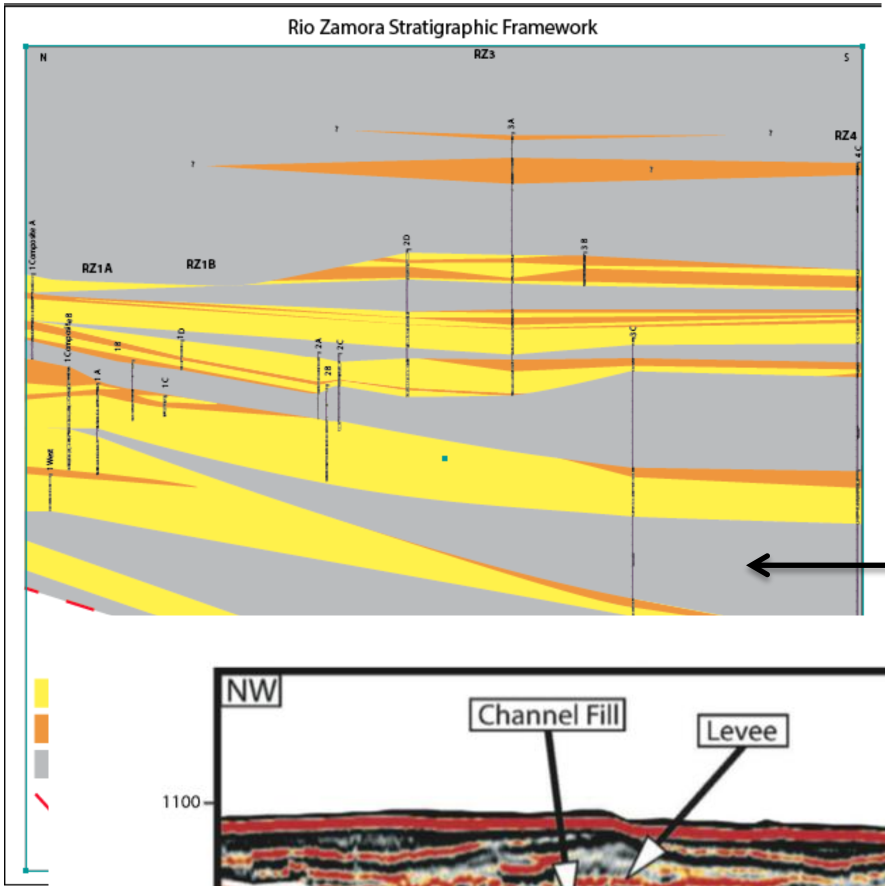
Basin-Scale Stratigraphic Framework: Magallanes Basin, Chile

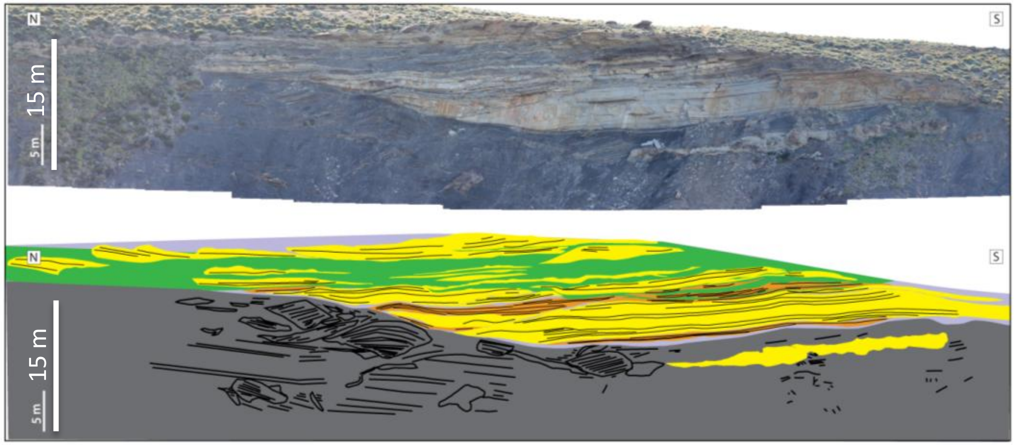


Facies Associations and Stratigraphic Architecture

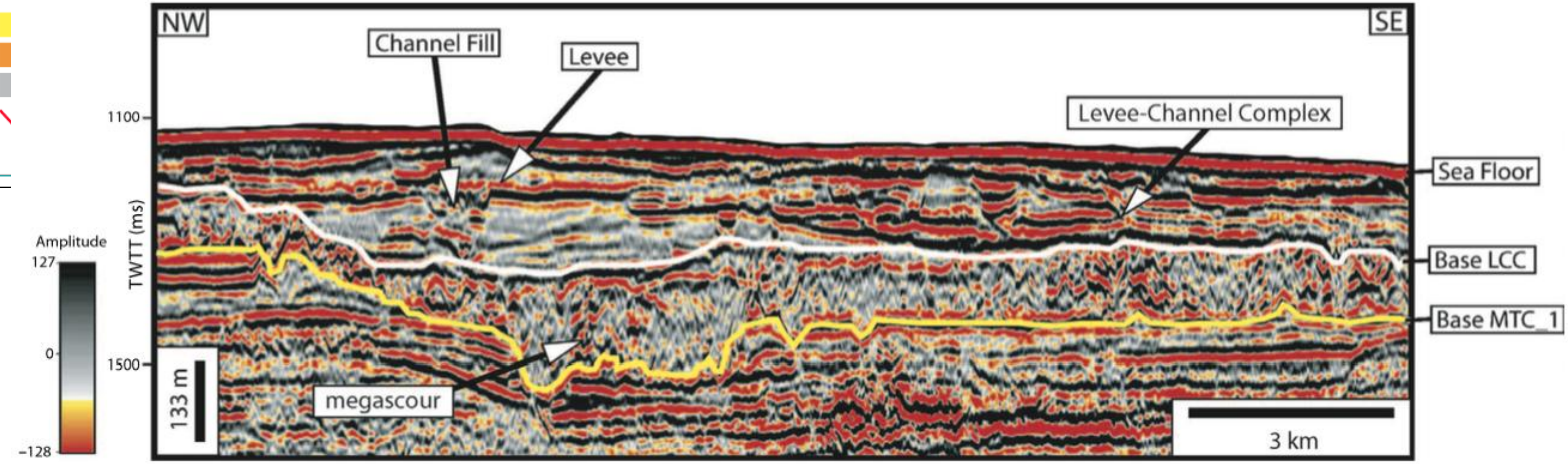


Regional Framework and Importance of MTDs



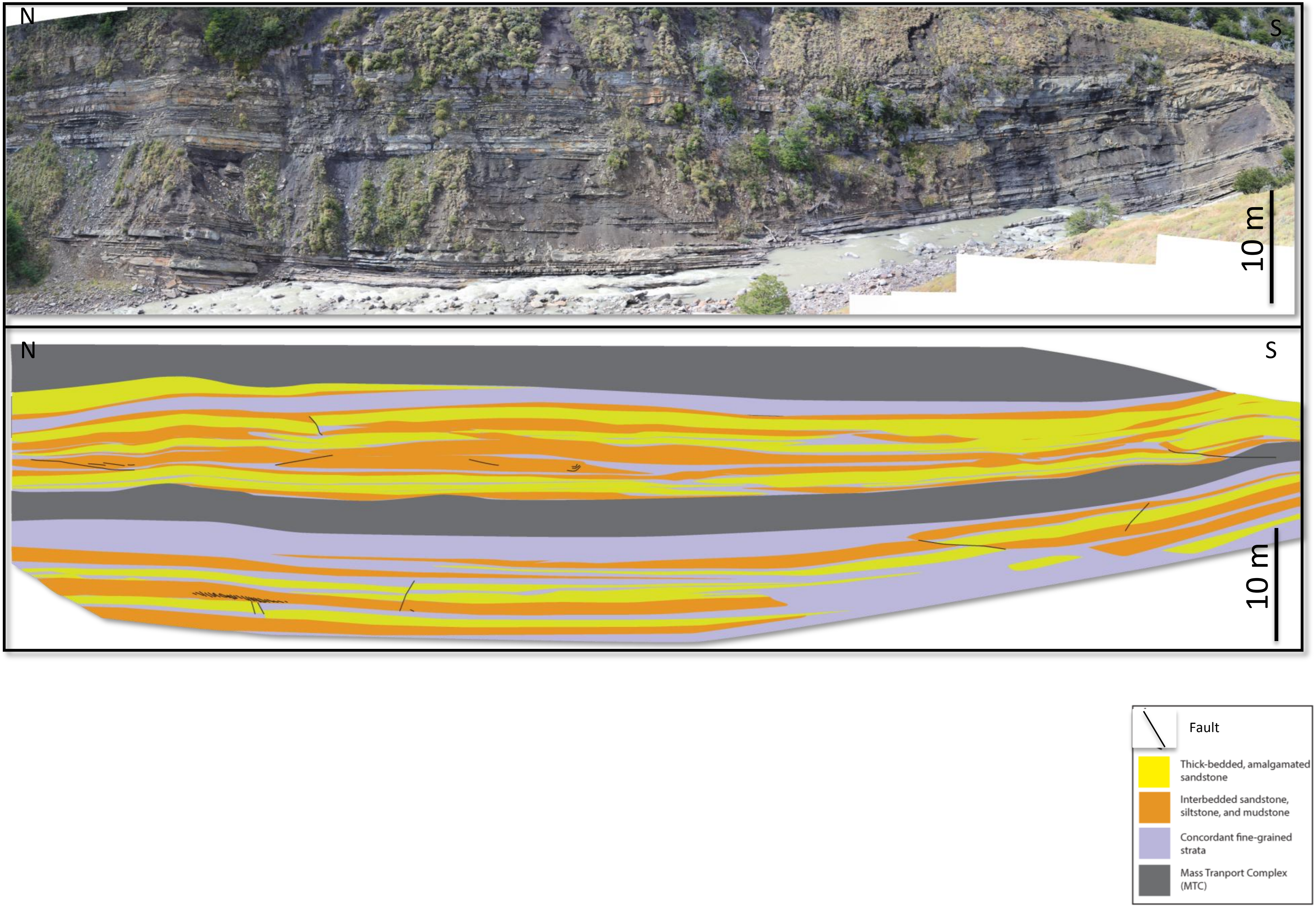


Downdip thickening of MTD intervals



Moscardelli et al. (2006); *AAPG Bulletin*

Intrastratal Deformation (ISD): Outcrop Example 1



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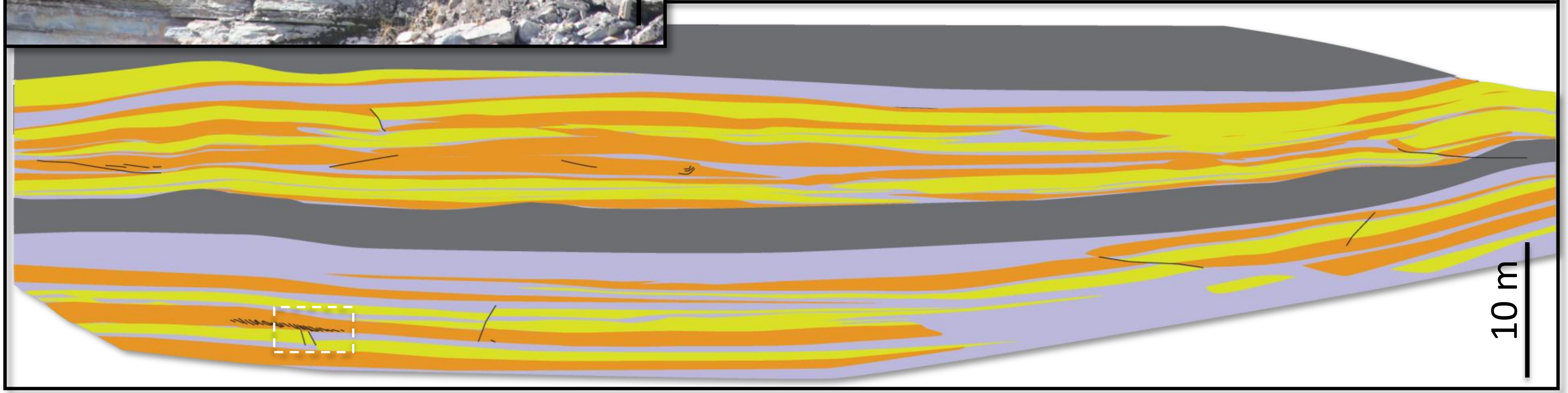
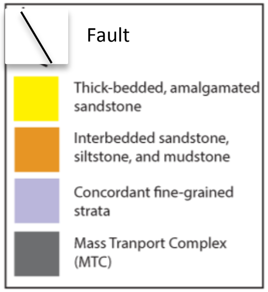
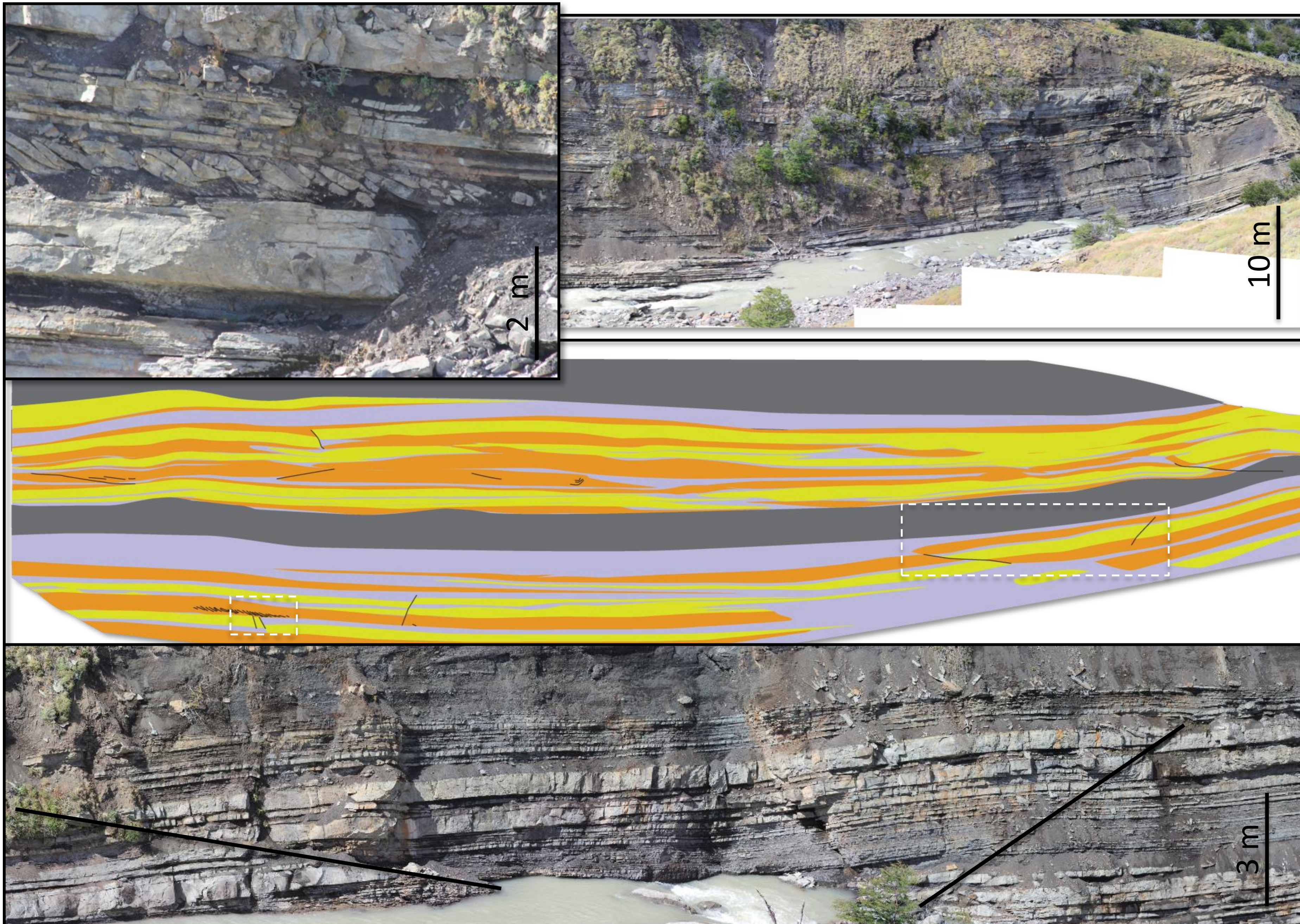




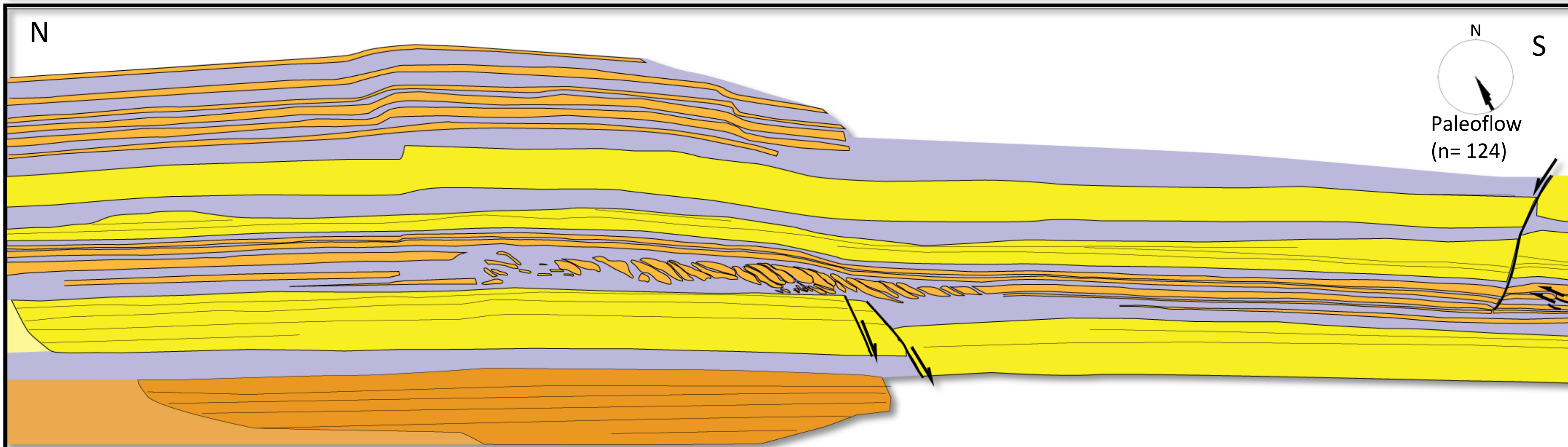
Intrastratal Deformation (ISD): Outcrop Example 1

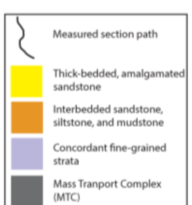


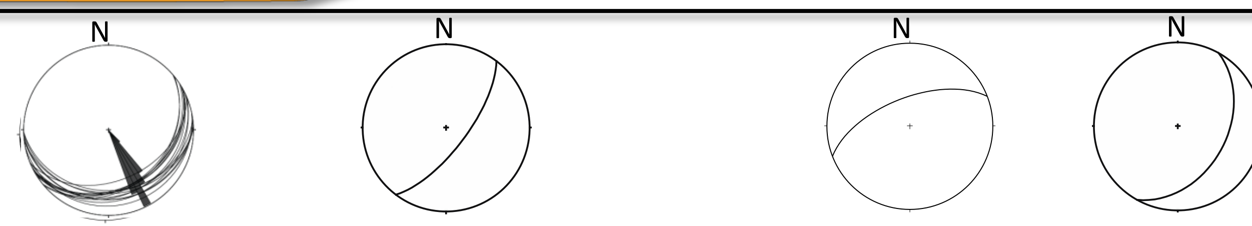
Intrastratal Deformation (ISD): Outcrop Example 1

- Measured section path
- Thick-bedded, amalgamated sandstone
- Interbedded sandstone, siltstone, and mudstone
- Concordant fine-grained strata
- Mass Tranport Complex (MTC)

Intrastratal Deformation (ISD): Outcrop Example 1







Imbricate segments

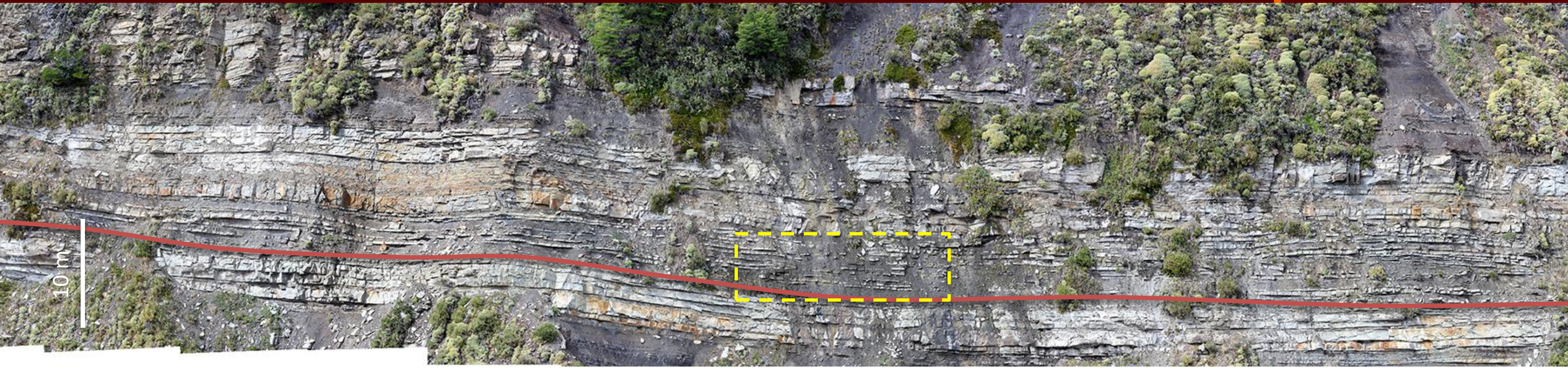
Normal Fault 1

Normal Fault 2

Reverse Fault 1

Intrastratal Deformation (ISD): Outcrop Example 2

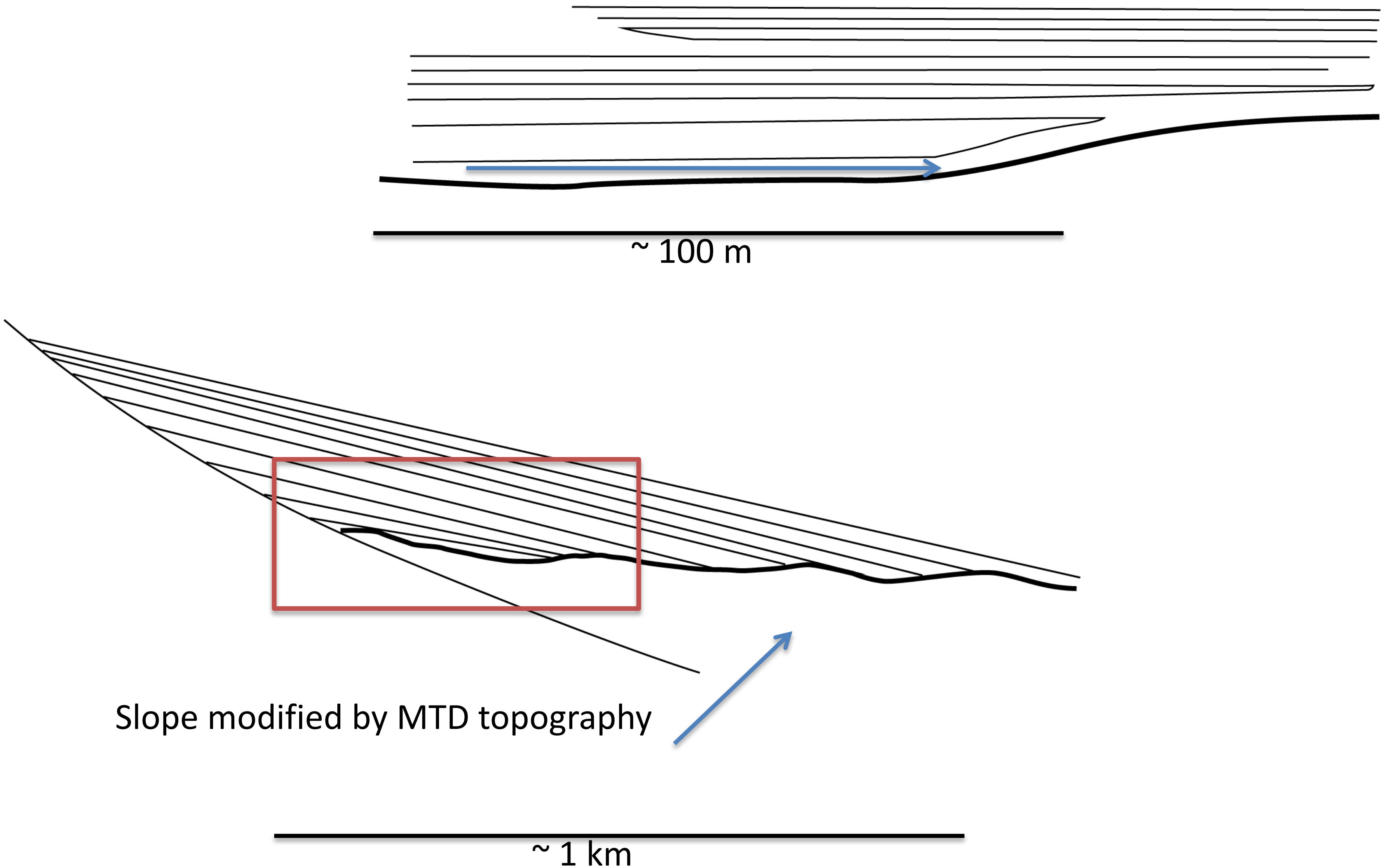
Intrastratal Deformation (ISD): Outcrop Example 3



Intrastratal Deformation (ISD): Outcrop Example 4

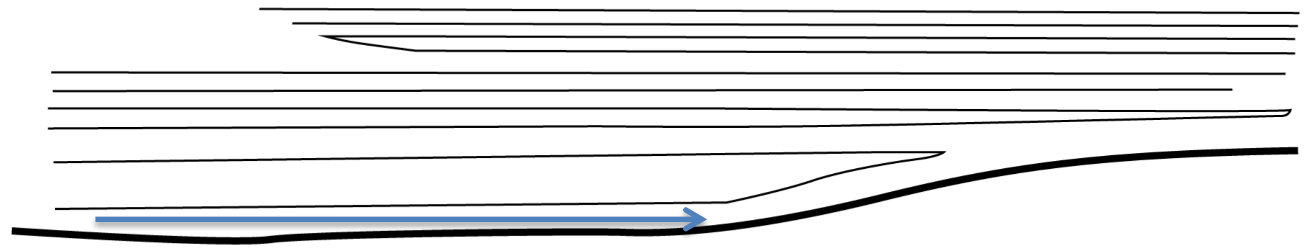
Intrastratal Deformation (ISD): Outcrop Example 5

Conceptual Model for Buttressed Down-Slope Deformation

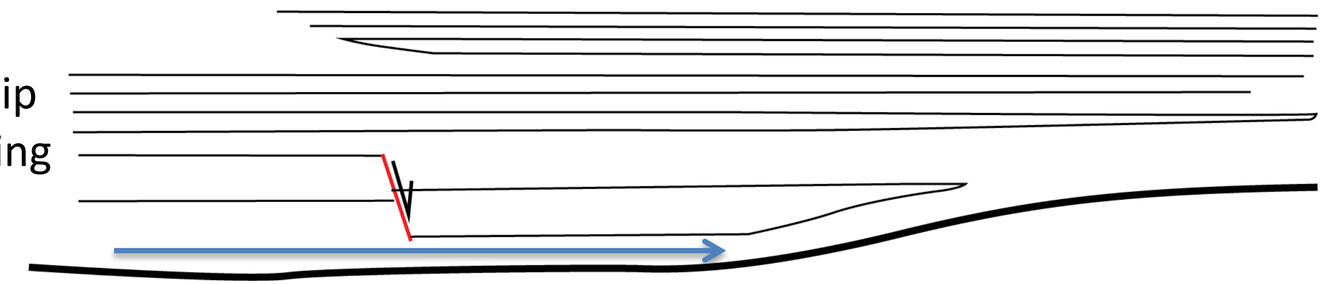


Conceptual Model for Buttressed Down-Slope Deformation

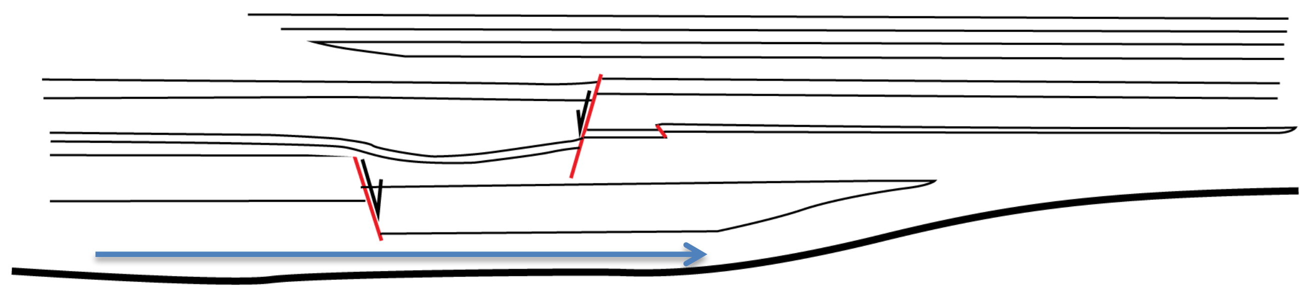
Slip along weak layer in mud-prone strata



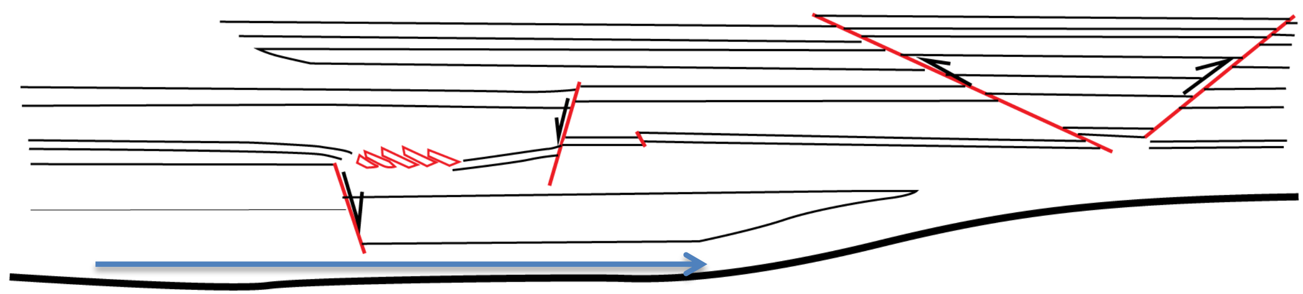
Extension in response to slip and evacuation of underlying strata



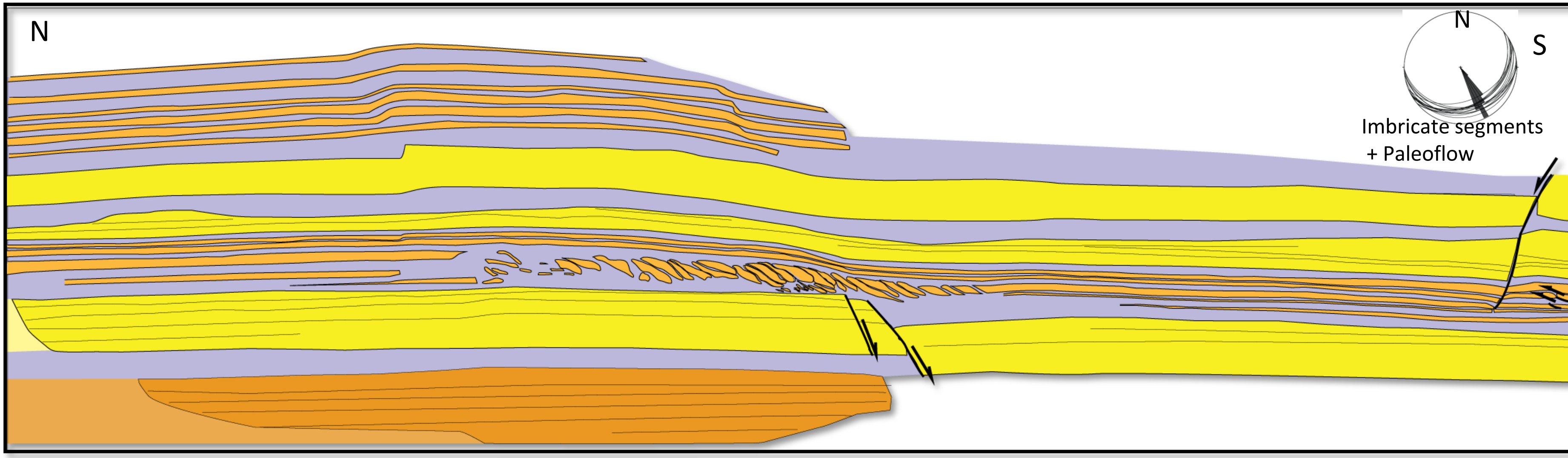
Flexure and rotation of individual beds



Faulting of flexed beds and compression due to downslope MTD buttress



Questions to Consider



- Are these intrastratal deformational features more common in slope deposits than currently recognized?
- To what extent do these features contribute to reservoir hetereogeneity (e.g., baffles/barriers to flow)?
- Can we predict the occurrence or location of sub-seismic-scale gravitational deformation based on mapping of MTDs and associated sand-prone deposits?

Thank You

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