

# **Bypass-Dominated Mud-Rich Channel-Fill Deposits of the Paleogene Scripps/Ardath Formation at Tourmaline Beach, San Diego, CA: An Analog for Low Net-to-Gross Slope Canyon and Channel Systems\***

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## **Abstract**

Over the past two decades, hydrocarbon exploration for turbidite channel reservoirs has been mostly focused on sediments deposited within mid-slope to lower slope environments of passive margin systems. In recent years, exploration has also been focused on the hydrocarbon prospectivity of channelized systems in more proximal slope settings. The Paleogene Ardath and Scripps Formations are exposed in a series of well-exposed coastal cliff outcrops in the vicinity of San Diego, CA, USA. These outcrops are composed of mud- and sand-rich submarine canyon and channel-fill deposits, which are interpreted to have been deposited in proximal submarine slope environments. As such, they are potentially a useful analog for comparing to proximal canyon systems viewed on seismic, and for reservoir modeling purposes. At Tourmaline Beach, the Scripps Formation is composed of a series of stacked channel elements within a larger-scale slope canyon or valley. These elements are stacked in an organized architectural relationship, with successively younger channel elements offlapping southward. The channel fill deposits are dominated by low net-to-gross (<20%), thin-bedded, heterolithic deposits and erosionally-based intervals of highly deformed, interbedded, mud-rich sediments. Thick-bedded sandstone deposits are rare. These channel deposits are interpreted to be dominated by a combination of thin-bedded, mud-rich turbidites and mass transport deposits. The thin-bedded turbidites are interpreted to reflect downslope bypass of turbidity currents. The stacked, organized pattern of the channel architecture reflects the underfilled nature of each erosional channel element, in which channel abandonment relief attracts subsequent turbidity currents and localizes successive channel elements in proximity. The low net-to-gross of the mud-rich bypass sediments and

mass transport deposits highlights the fact that reservoir presence and quality is a major risk factor in exploration for, and development of hydrocarbons in proximal slope channel and canyon systems. Thus, interpretation of these systems on seismic data should focus on the lithological nature of the channel fill deposits, leveraging channel patterns and seismic attributes, rather than just the presence of channel systems.

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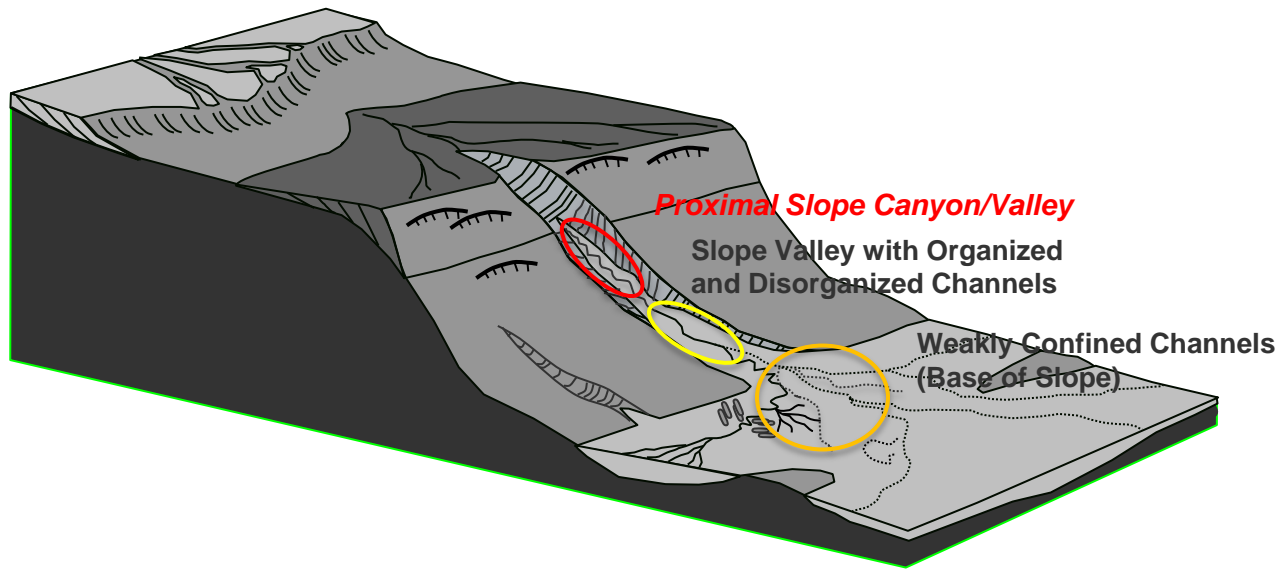
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**2014 AAPG Annual Convention & Exhibition  
April 9, Houston, TX**

# Deep Water Depositional System: Schematic Updip to Downtip Environments of Deposition

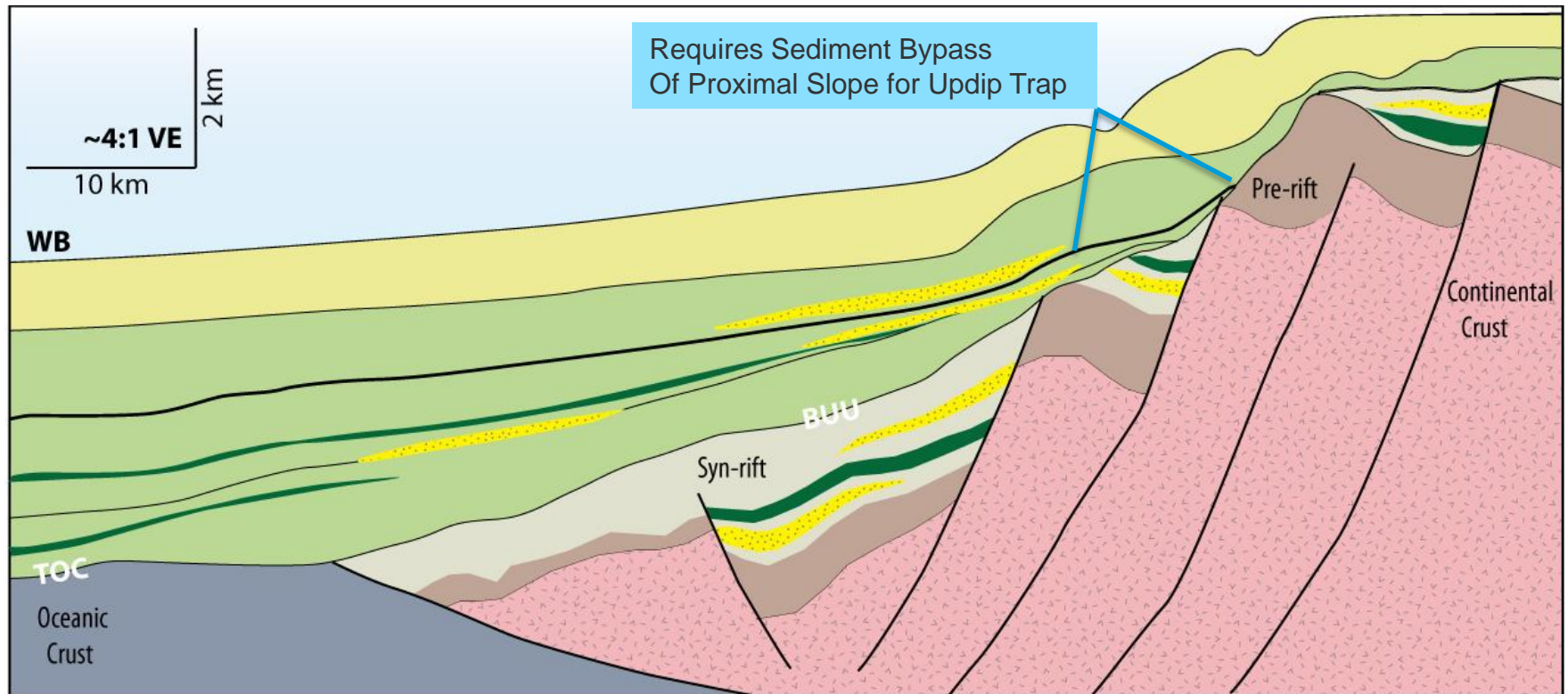


- Reservoir?
- Bypass?
- Updip Trap Potential?

- The majority of hydrocarbon reservoirs in deep water channelized turbidite systems discovered and studied over the past two decades have been interpreted as having been deposited in either medial to distal slope valleys or weakly confined channel systems deposited on passive continental margins .
  - Angola, Nigeria, Brazil, GOM
- There is currently considerable industry focus on turbidite systems associated with basin margin wedges in either early post-rift/drift margins or within active margin and structurally confined basins. Proximal slope canyons/valleys are a critical component of this reservoir system.
  - NW Africa, NE South America.
- What are the potential risks for hydrocarbon exploration?

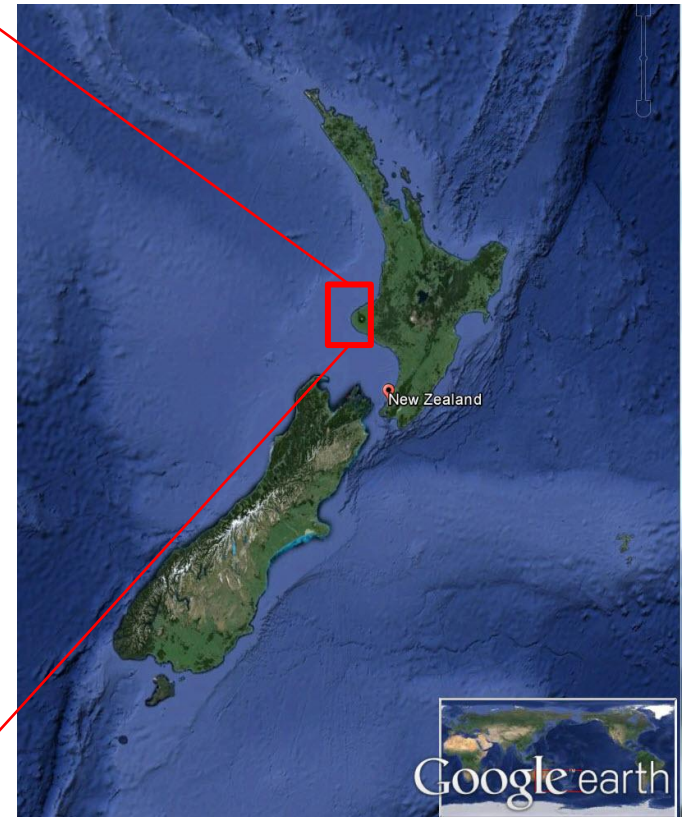
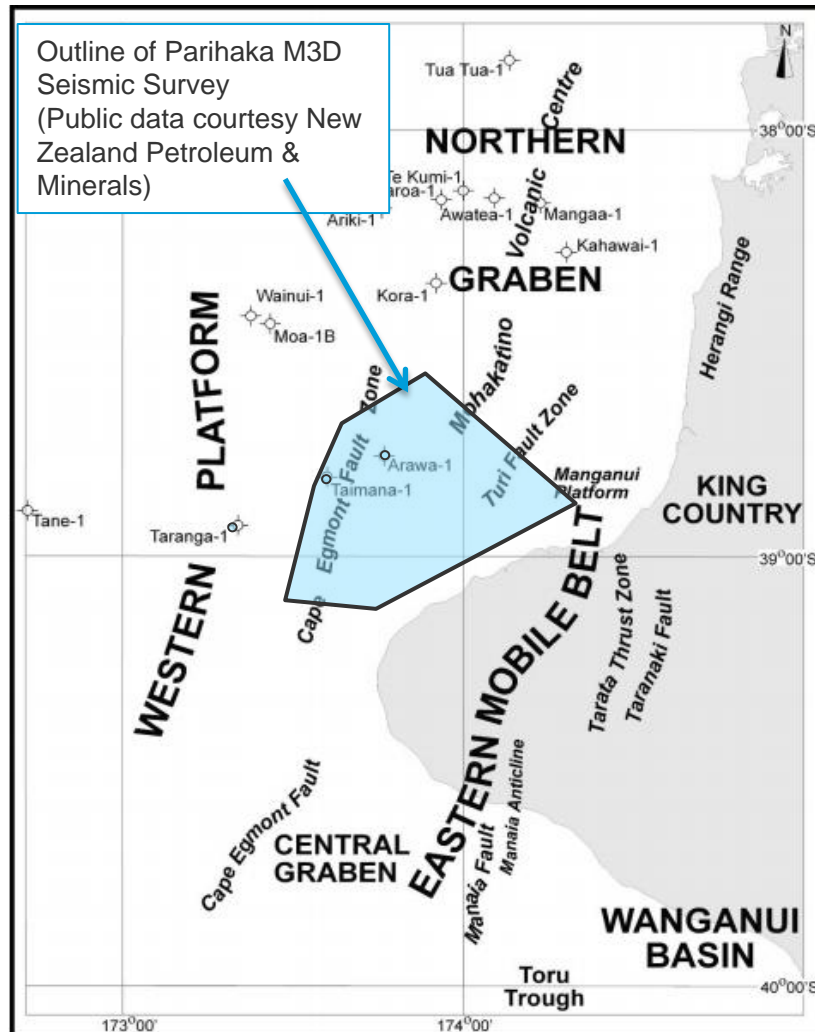
- **Proximal slope canyon/valley channel systems**
  - Exploration and reservoir context
- **Seismic architecture analog**
  - New Zealand Mio-Pliocene in the Taranaki Basin.
- **Eocene Scripps Formation at Tourmaline Beach**
  - Facies
  - Architecture
  - Interpreted Process and EOD
- **Summary**

# Basin Margin Wedge Turbidite System Schematic Cross Section



Slide courtesy of Chevron FEA New Ventures Team

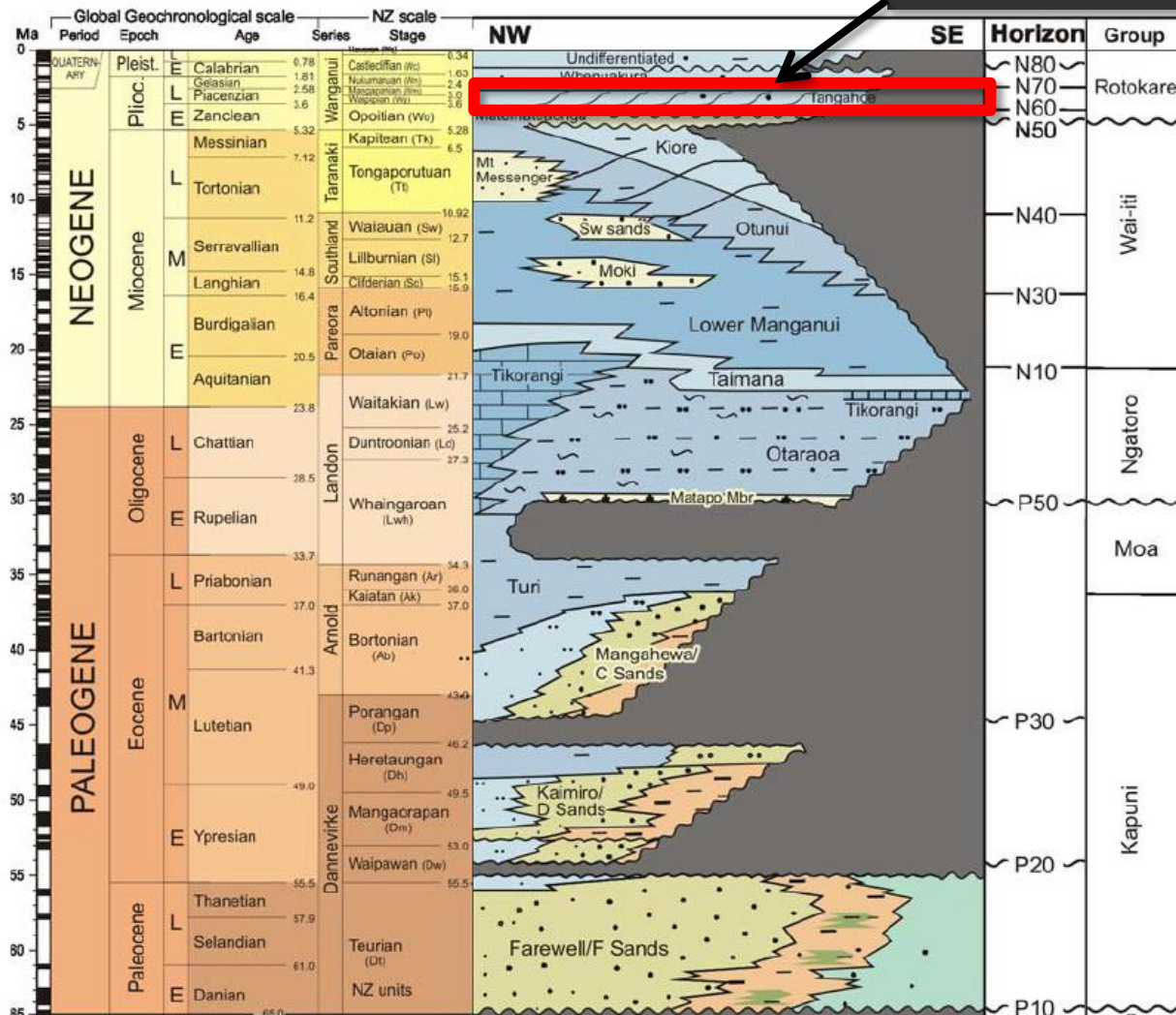
# Mio-Pliocene Canyon to Basin Floor Turbidite System: Taranaki Basin, New Zealand



# Tertiary Taranaki Basin Stratigraphy

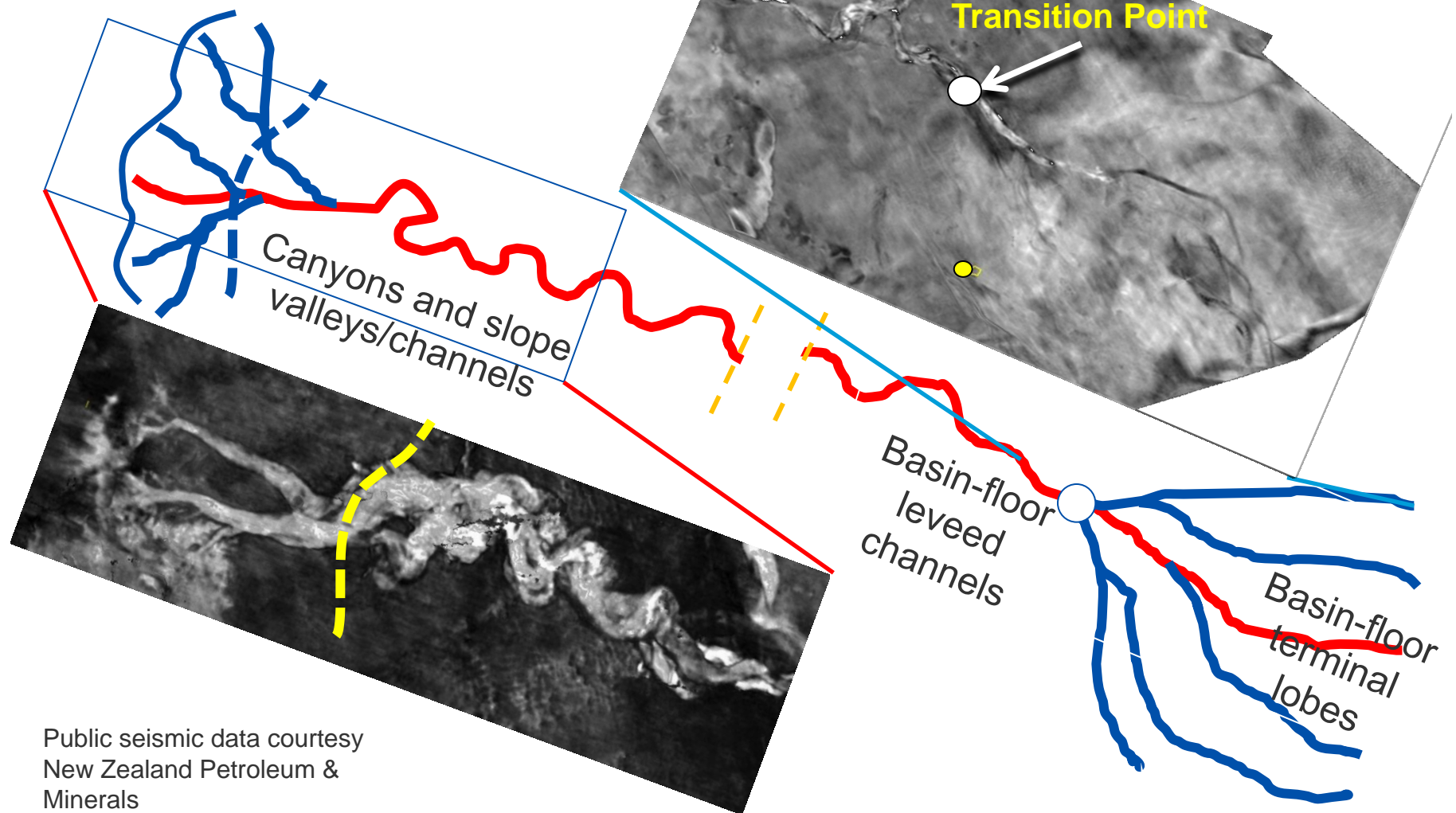


Giant Foresets Fm.

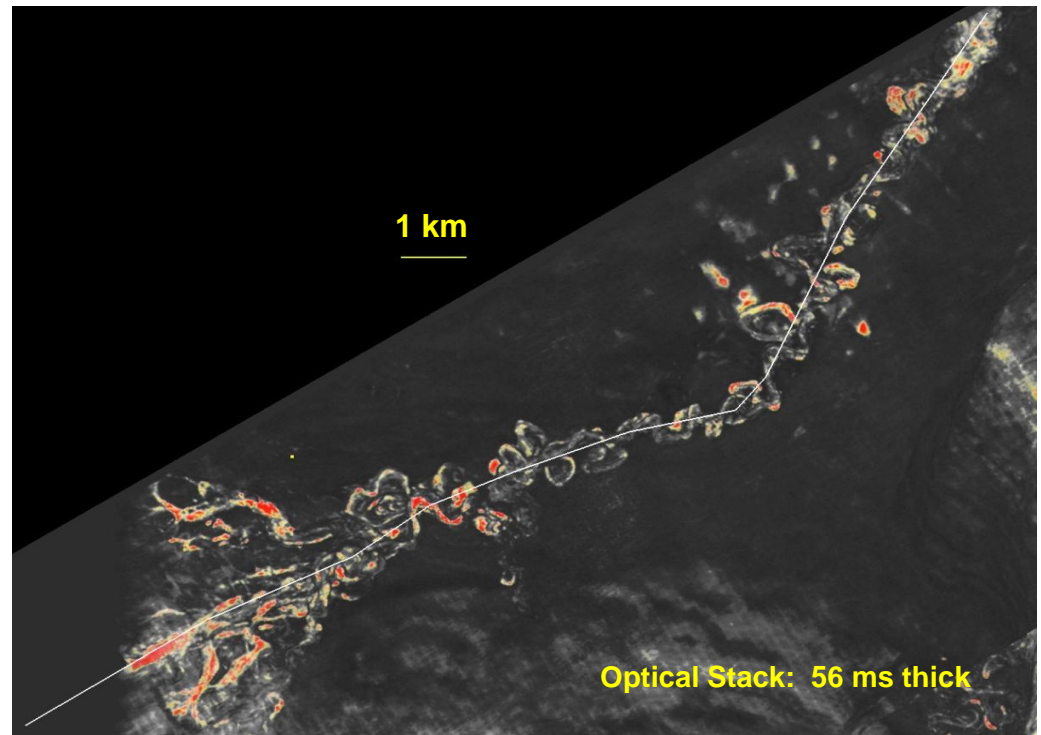
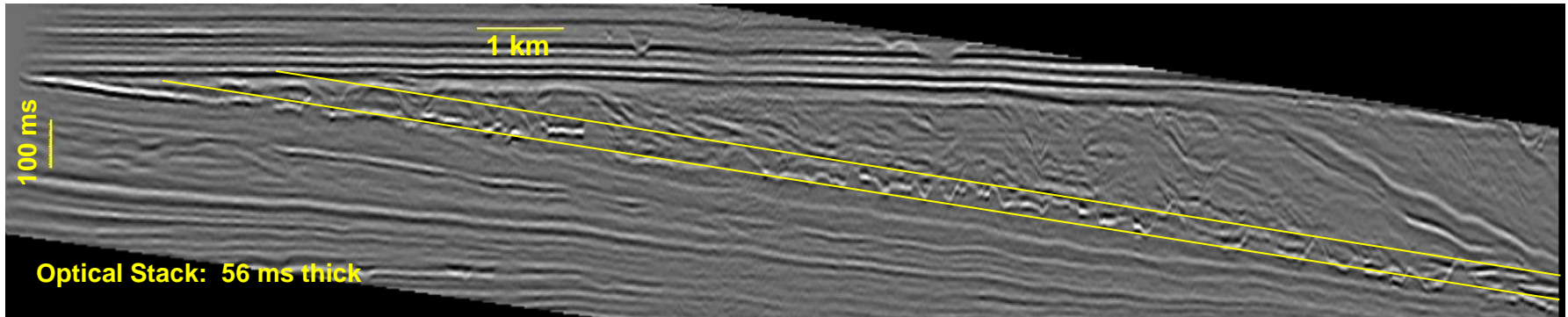


From Baur et al., 2010

# Mio-Pliocene Taranaki Basin Turbidite System from Proximal to Distal



# Pliocene Giant Foresets Formation: Taranaki Basin, New Zealand

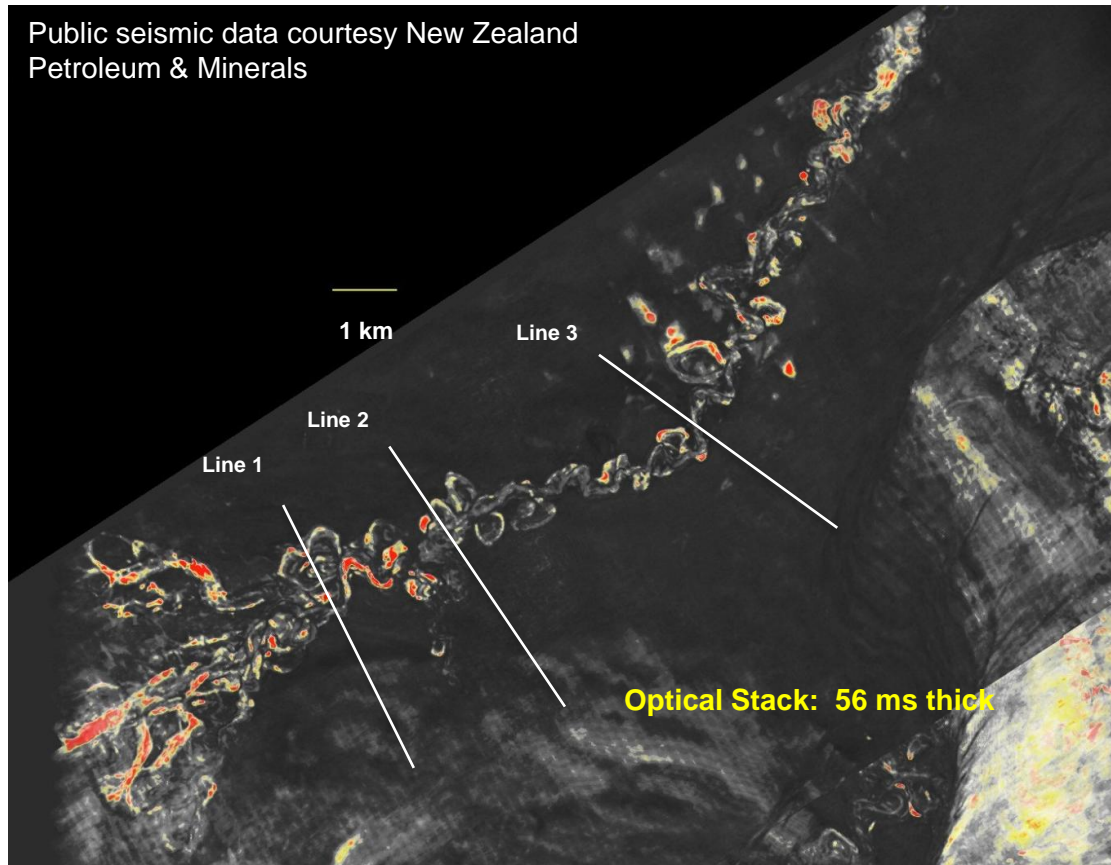


(Public seismic data courtesy New Zealand Petroleum & Minerals)

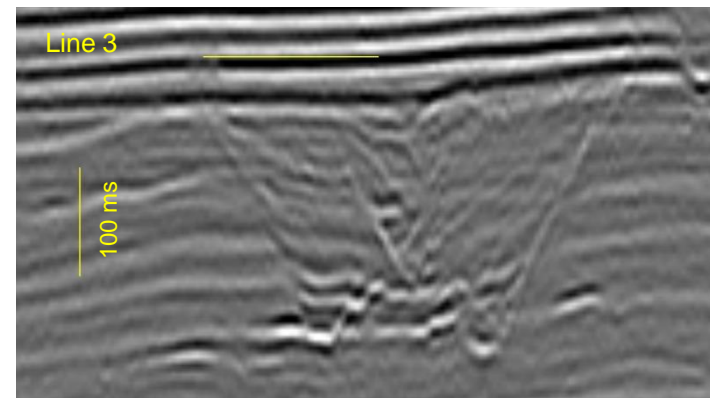
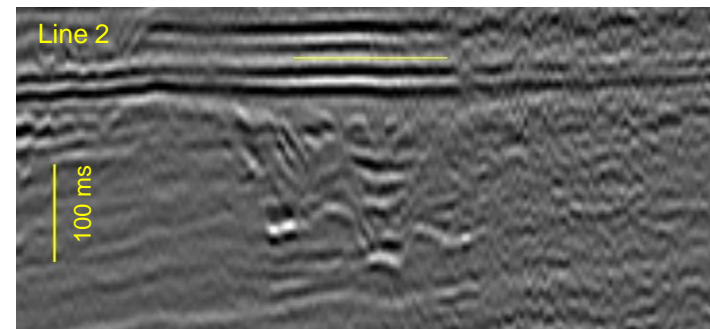
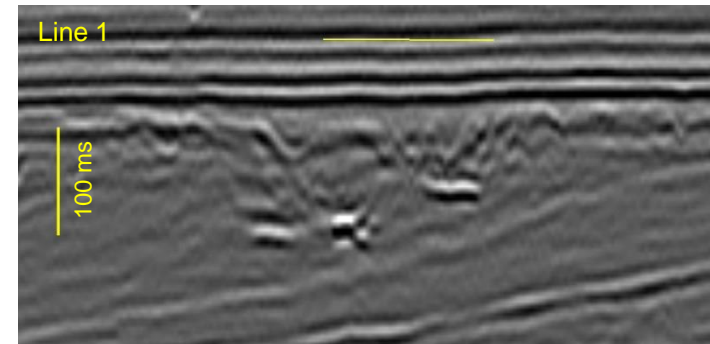
# Pliocene Giant Foresets Canyon Fill Cross Sections, Taranaki Basin, New Zealand



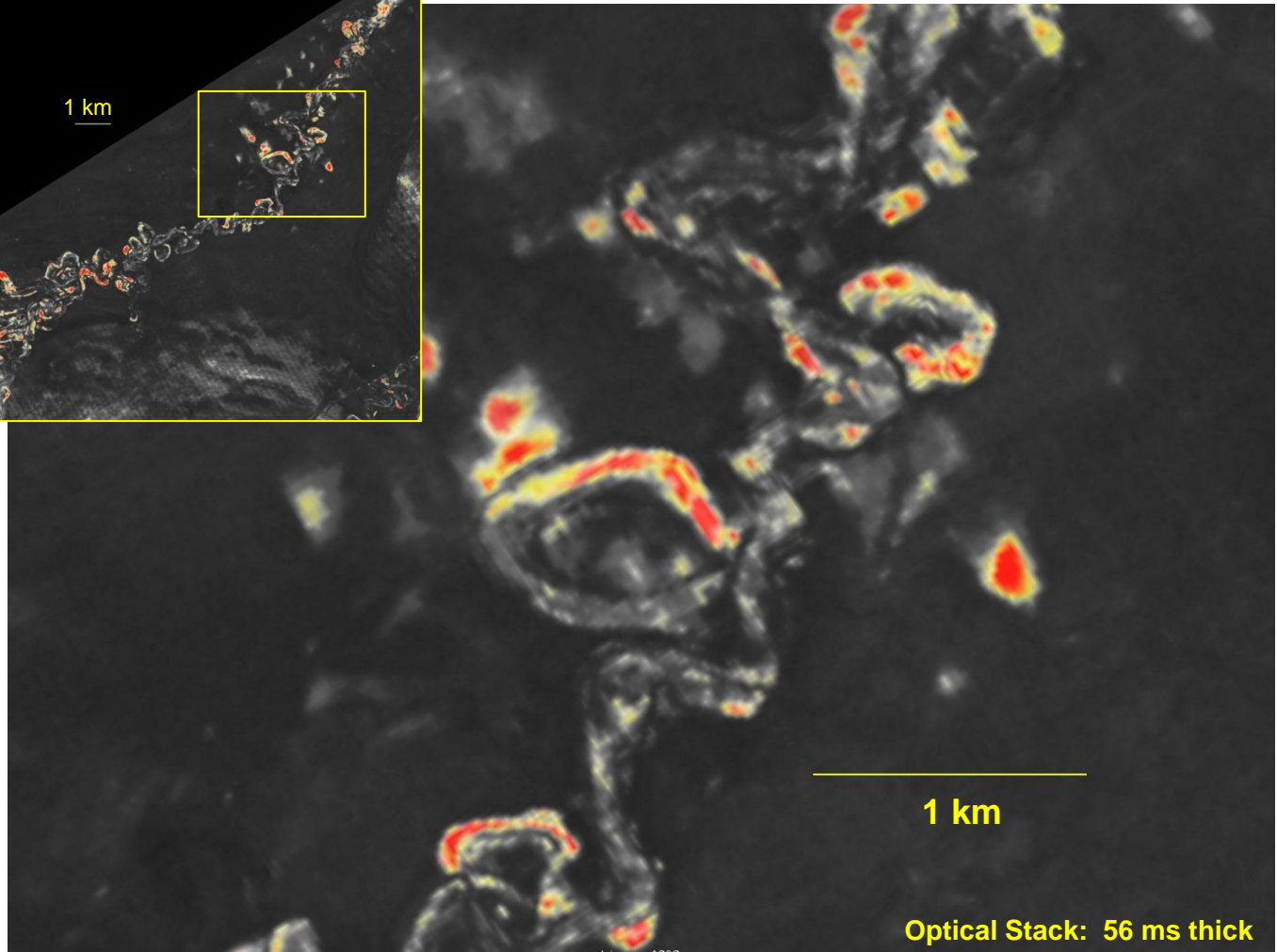
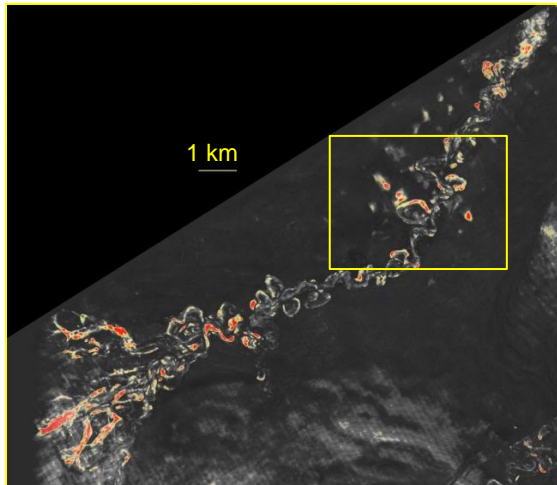
Public seismic data courtesy New Zealand Petroleum & Minerals



- Channelized sediments restricted to the basal portion of the channel fill.
- These channels are largely a conduit for bypassing sediment to more basinward areas.

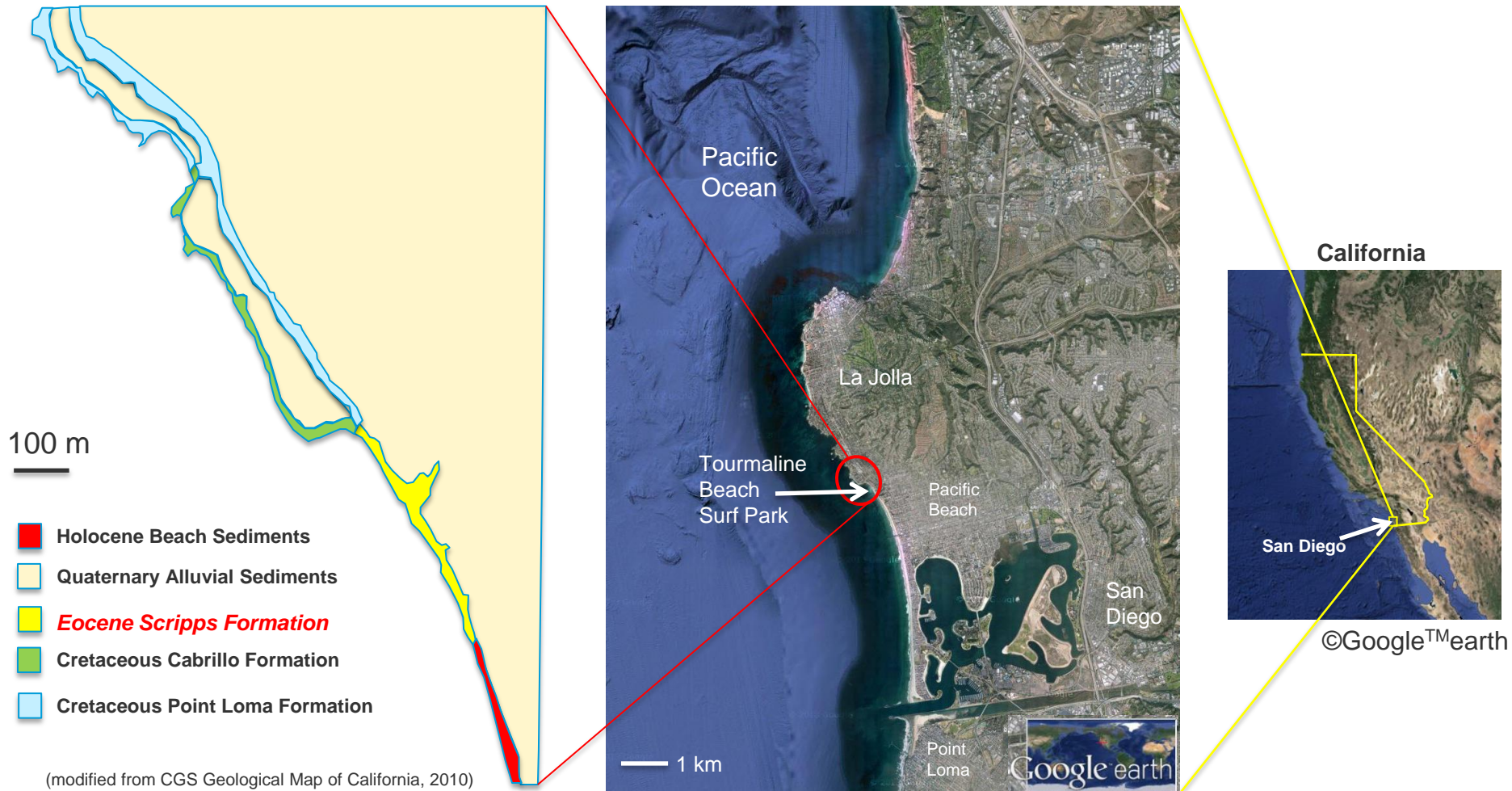


# Pliocene Giant Foresets Formation: Amplitude Variability Within Organized Channel Complex

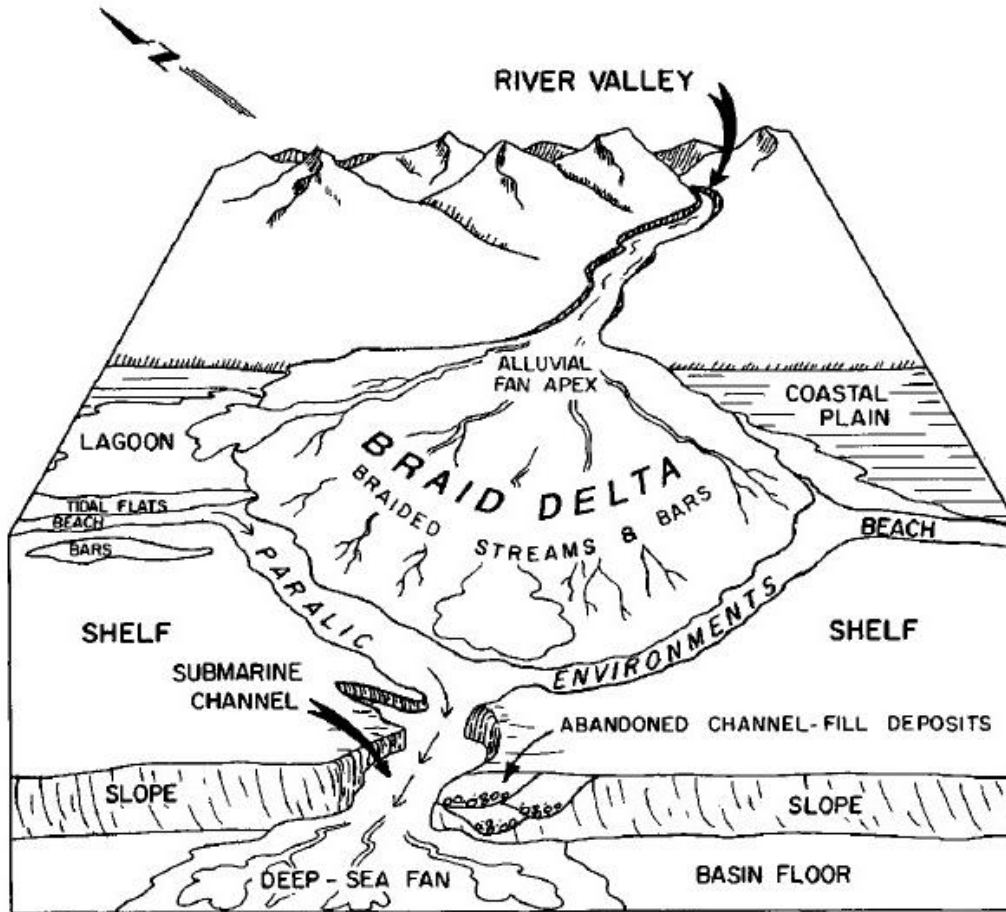


Variable Amplitudes over the Optical Stack indicate potential for significant variability of lithology

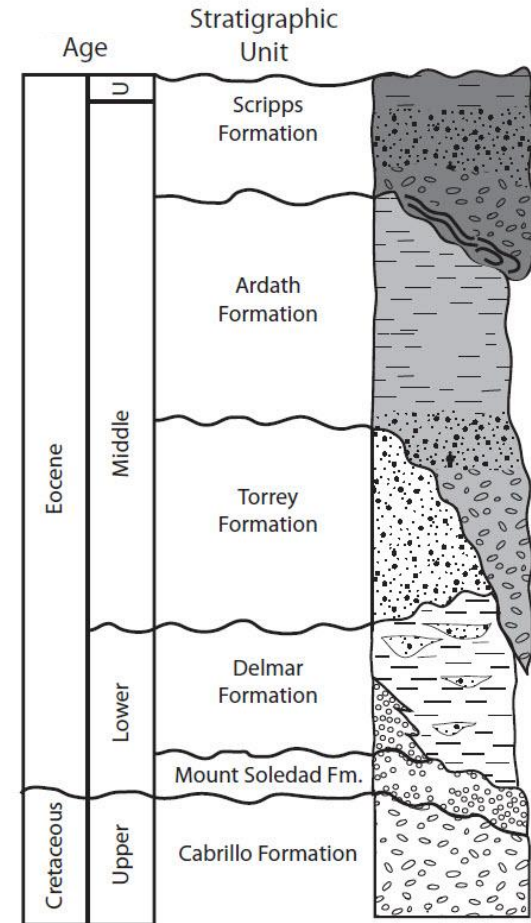
# Tourmaline Beach Surf Park, California: Location Map



# Schematic Depositional Environments of the Eocene La Jolla Group in the San Diego Region

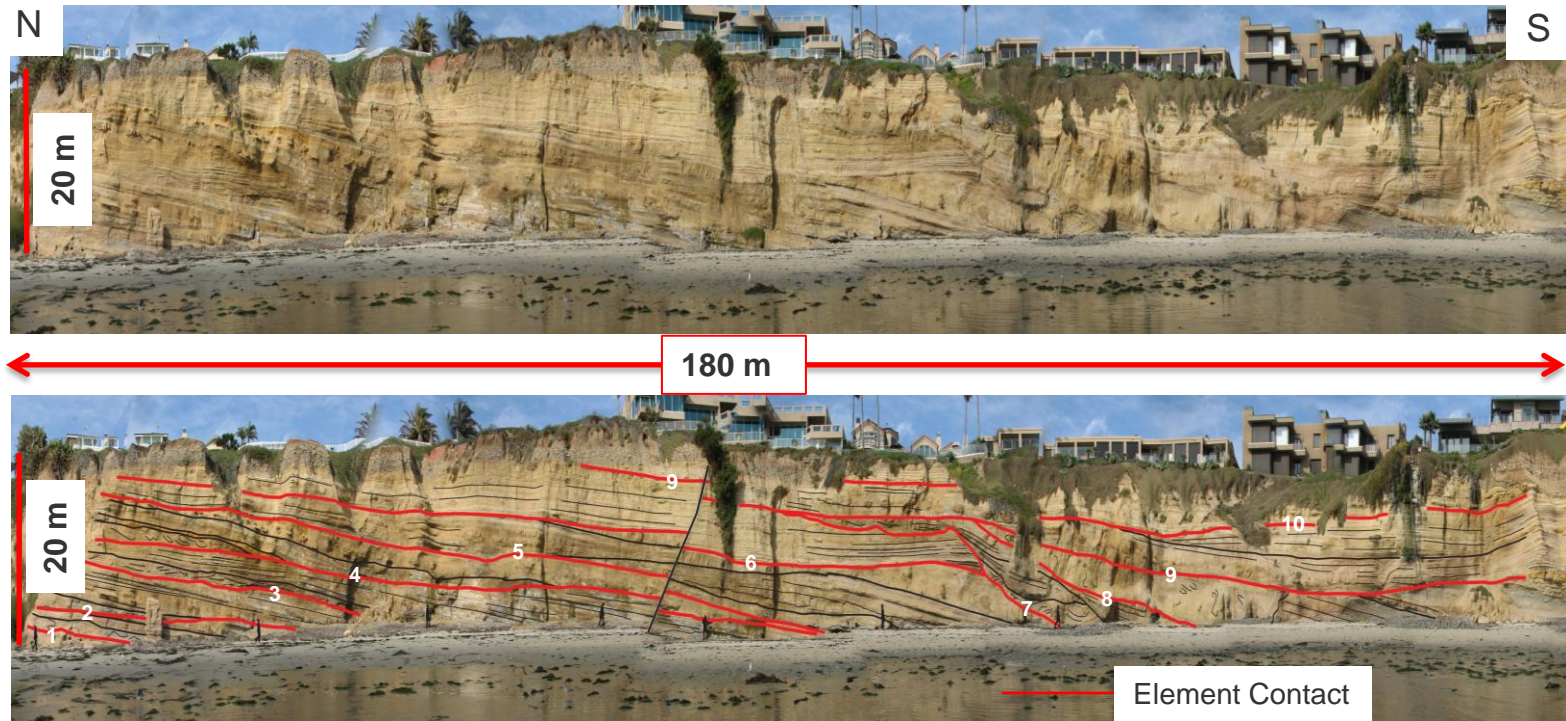


from May and Warme, 1991.



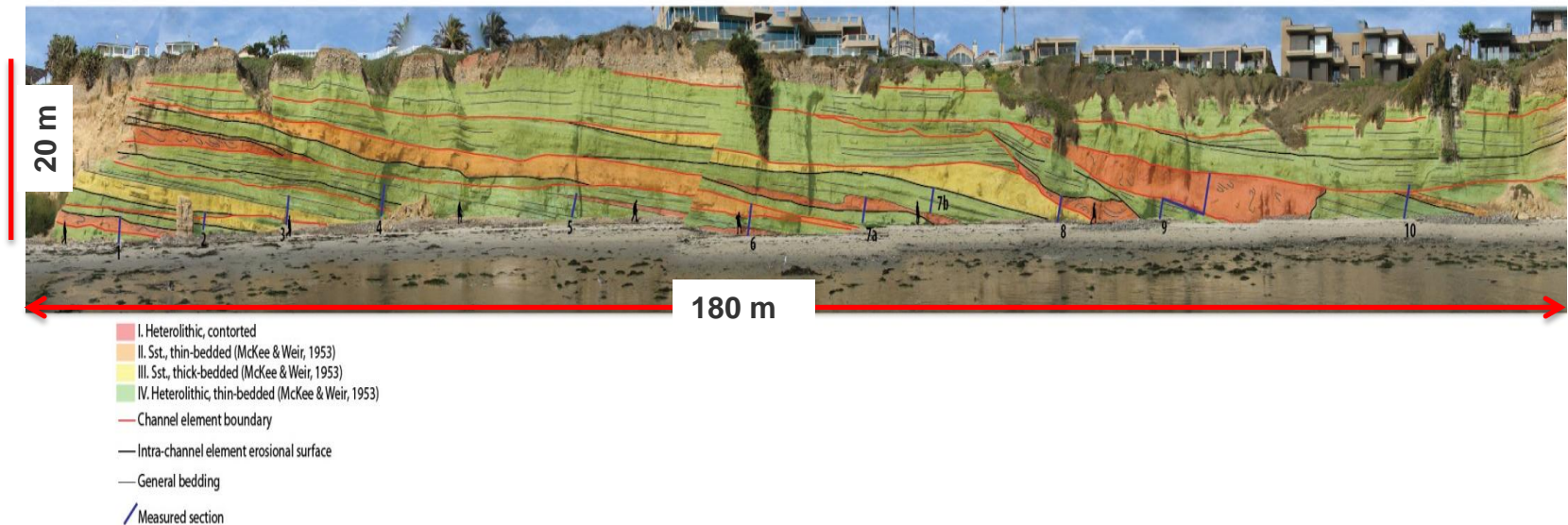
from Stright, 2011, after Campion et al., 1996, and May and Warme, 1991.

# Eocene Scripps Formation: Tourmaline Beach, CA



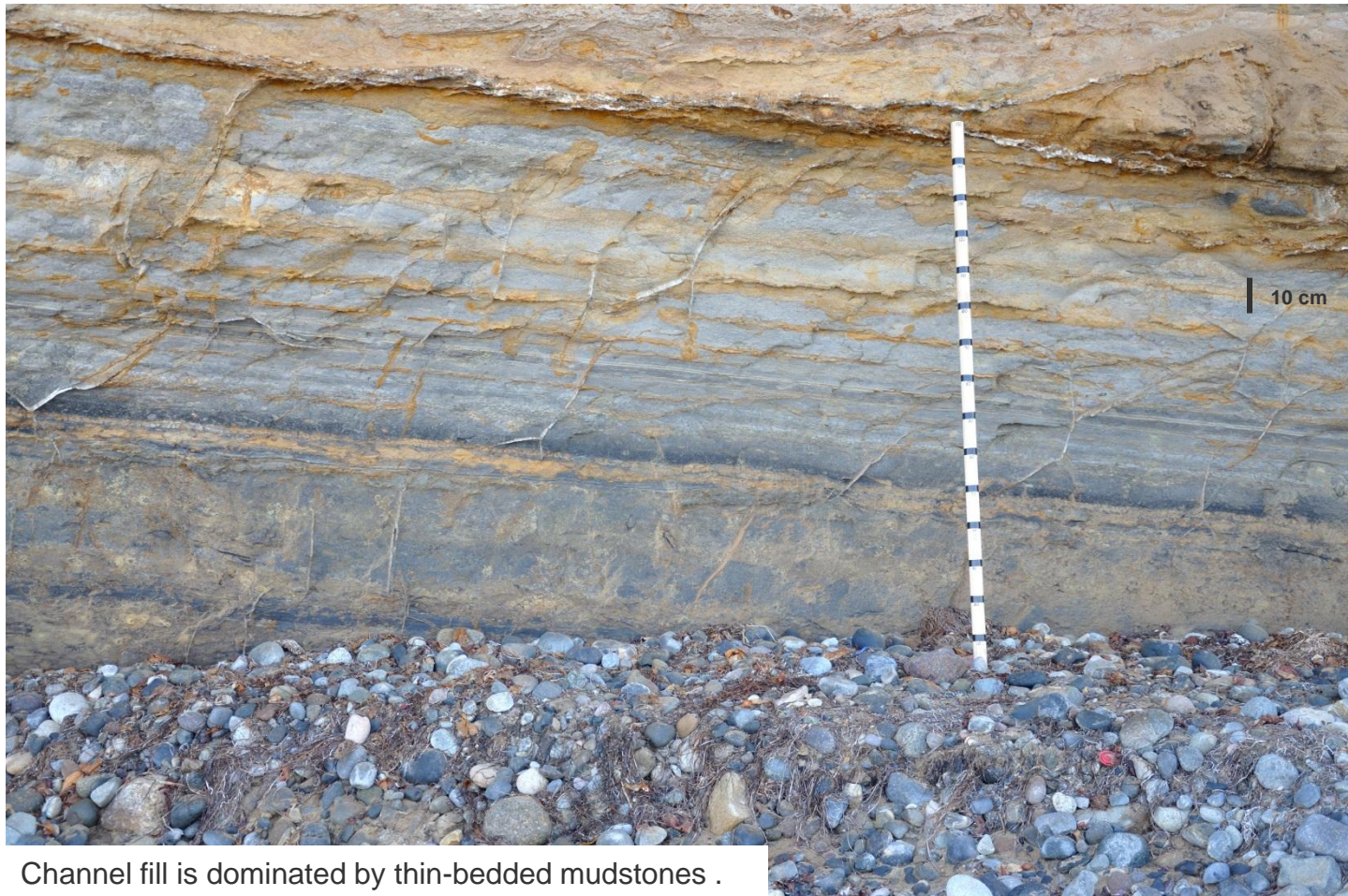
Organized Channel Complex: Succession of organized channel elements which offlap and become progressively younger to the south. This channel complex is interpreted to have been deposited within a larger scale submarine canyon/valley.

# Low Net-to-Gross Channel Complex: Paleogene Scripps Formation; Tourmaline Beach, San Diego, CA



- Facies within the channel elements are dominated by very low net-to-gross heterolithic, thin-bedded mudstones and sandstones. The volume of sandstone within these heterolithic intervals is less than 15%, and generally <10%.
- Intervals of highly contorted beds of the thin-bedded heterolithics are interstratified throughout the section, and are particularly common overlying channel element boundaries.
- Very Low NTG Organized Channel Complex**

# Very Low Net-to-Gross Thin-bedded Mudstone: Eocene Scripps Formation, Tourmaline Beach, CA



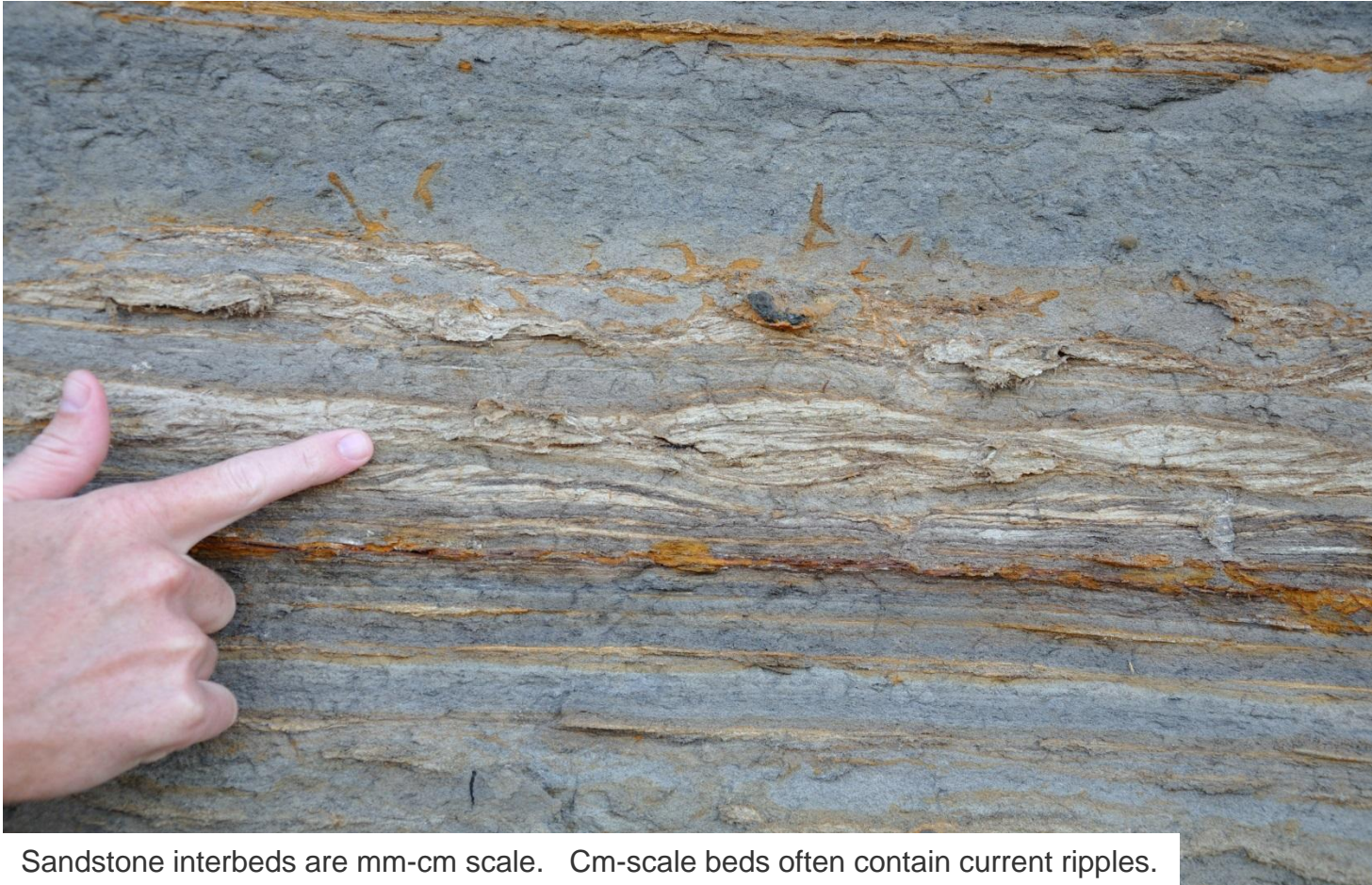
Channel fill is dominated by thin-bedded mudstones .

# Low Net-to-Gross Thin-Bedded Mudstone and Sandstone: Eocene Scripps Formation, Tourmaline Beach, CA



Buff "sandy" color of outcrop is deceiving. Thin-bedded intervals are usually >85% mudstone

# Thin-Bedded Current-Rippled and Scoured Sandstone Beds: Eocene Scripps Formation, Tourmaline Beach, CA



Sandstone interbeds are mm-cm scale. Cm-scale beds often contain current ripples.

# Planar-laminated Sandstone: Eocene Scripps Formation, Tourmaline Beach, CA



Rare intervals of thicker-bedded laminated turbidite sandstones.

# Erosional Channel Element Contacts: Eocene Scripps Formation, Tourmaline Beach, CA



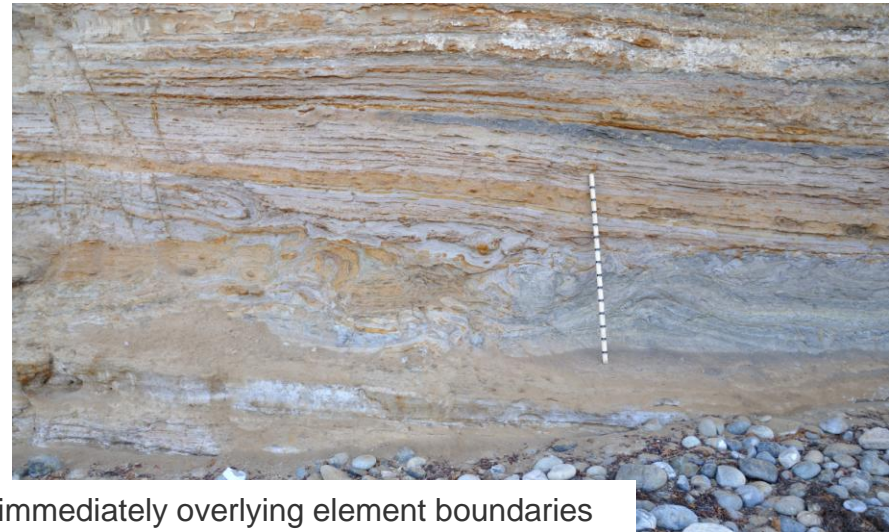
Erosional scour at element boundaries

# Intra-Element Erosional Scours: Eocene Scripps Formation, Tourmaline Beach, CA



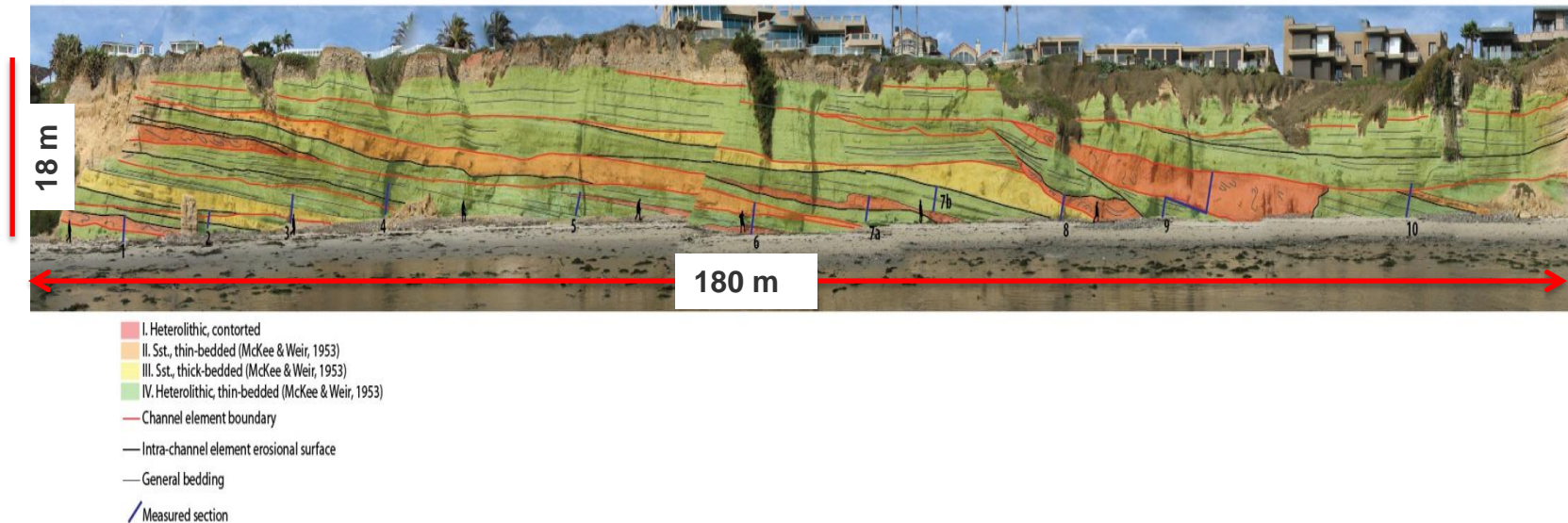
Intra-element scour and fill is also common within the thin-bedded heterolithics

# Soft Sediment Deformation of Thin-Bedded Heterolithics: Local Slumping of Channel Margins: Eocene Scripps Formation, Tourmaline Beach, CA



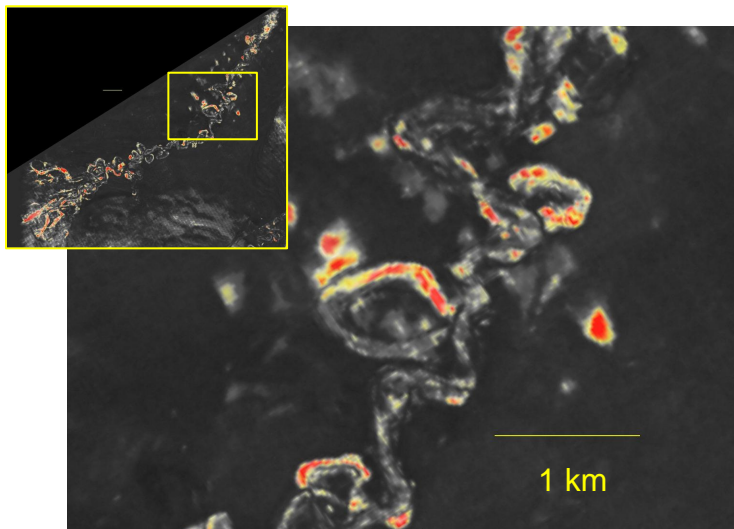
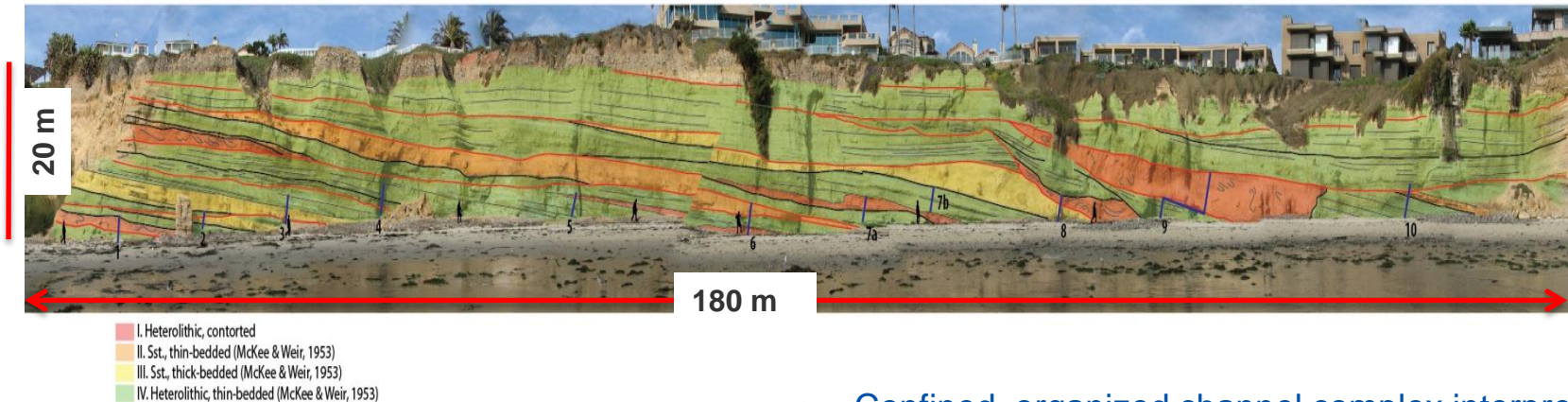
Soft sediment deformation is common, particularly in intervals immediately overlying element boundaries

# Slope Bypass Canyon/Valley: Eocene Scripps Formation; Tourmaline Beach, San Diego, CA



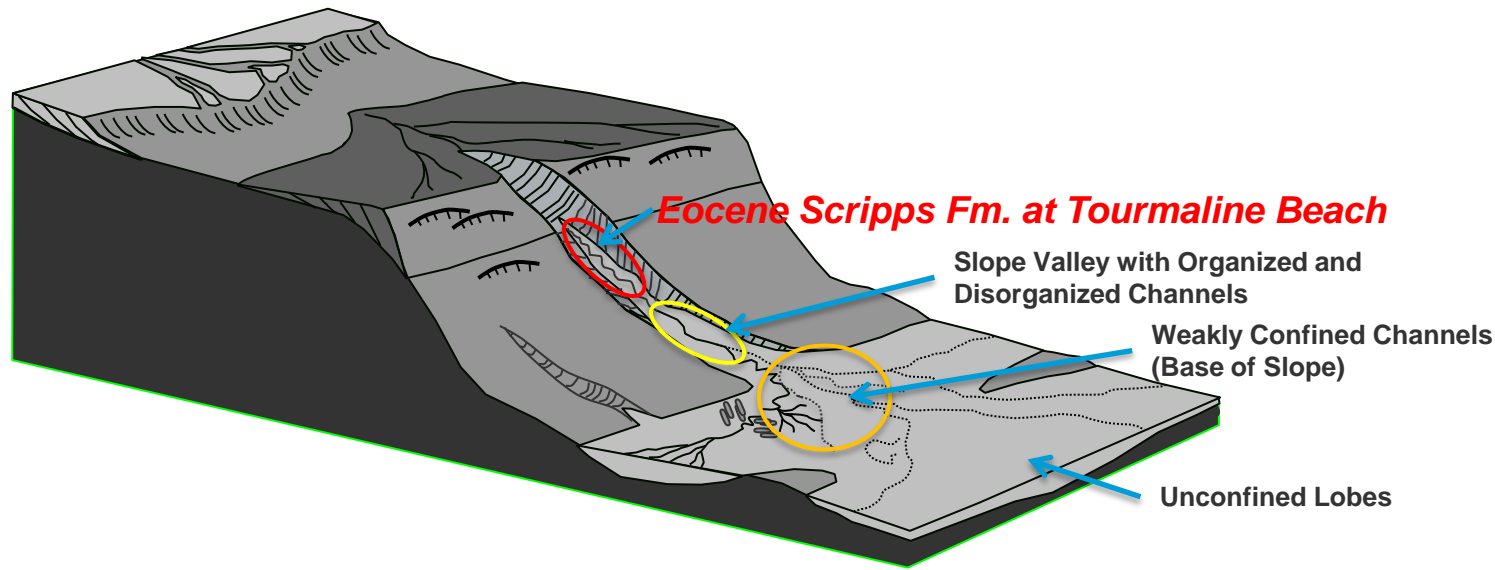
- Organized offlapping channel complex
- Very low net-to-gross heterolithic, thin-bedded mudstones and sandstones.
  - NTG <15%
- Thin beds interpreted as fine-grained “tails” of gravity currents in which the bulk of the sediment bypassed through the channels.
- Erosional scour dominant at element boundaries and within elements.
- Local soft sediment deformation and slumping common, and often overlying element boundaries
- **Slope Bypass Canyon/Valley Complex**

# Analogy Between Eocene Scripps Formation at Tourmaline Beach and the Pliocene Giant Foresets Formation in the Taranaki Basin.



- Confined, organized channel complex interpreted to exist within a larger erosional canyon/valley.
- Interpreted to be dominated by erosion and bypass processes.
- Very low NTG (<15%) in Scripps Fm. channel elements.
- Variable amplitude response indicative of variable lithology in the upper slope canyon channels of the Giant Foresets Fm.
  - Variable/Low NTG?
- Scripps Fm. at Tourmaline Beach likely deposited in a similar environment.

# Deep Water Depositional System: Schematic Updip to Downtip Environments of Deposition



- Using the Scripps Formation at Tourmaline Beach and the Pliocene Giant Foresets Fm. as analogs, channel systems in proximal slope valleys/canyons have a high risk of being dominated by erosion and bypass processes, leaving behind thin-bedded, low NTG bypass sediments and slumped deposits.
  - These sediments have poor reservoir potential.
- The bypass nature of these channel complexes is generally not “complete”. There is still probably enough sand within the valley/canyon so that it would make a high risk updip trap for hydrocarbons deposited in the more distal turbidite systems.